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NAS 1.21:7056/supp. 6

Space Station Systems

A Bibliography
with Indexes

NASA SP-7056(06)
July 1988

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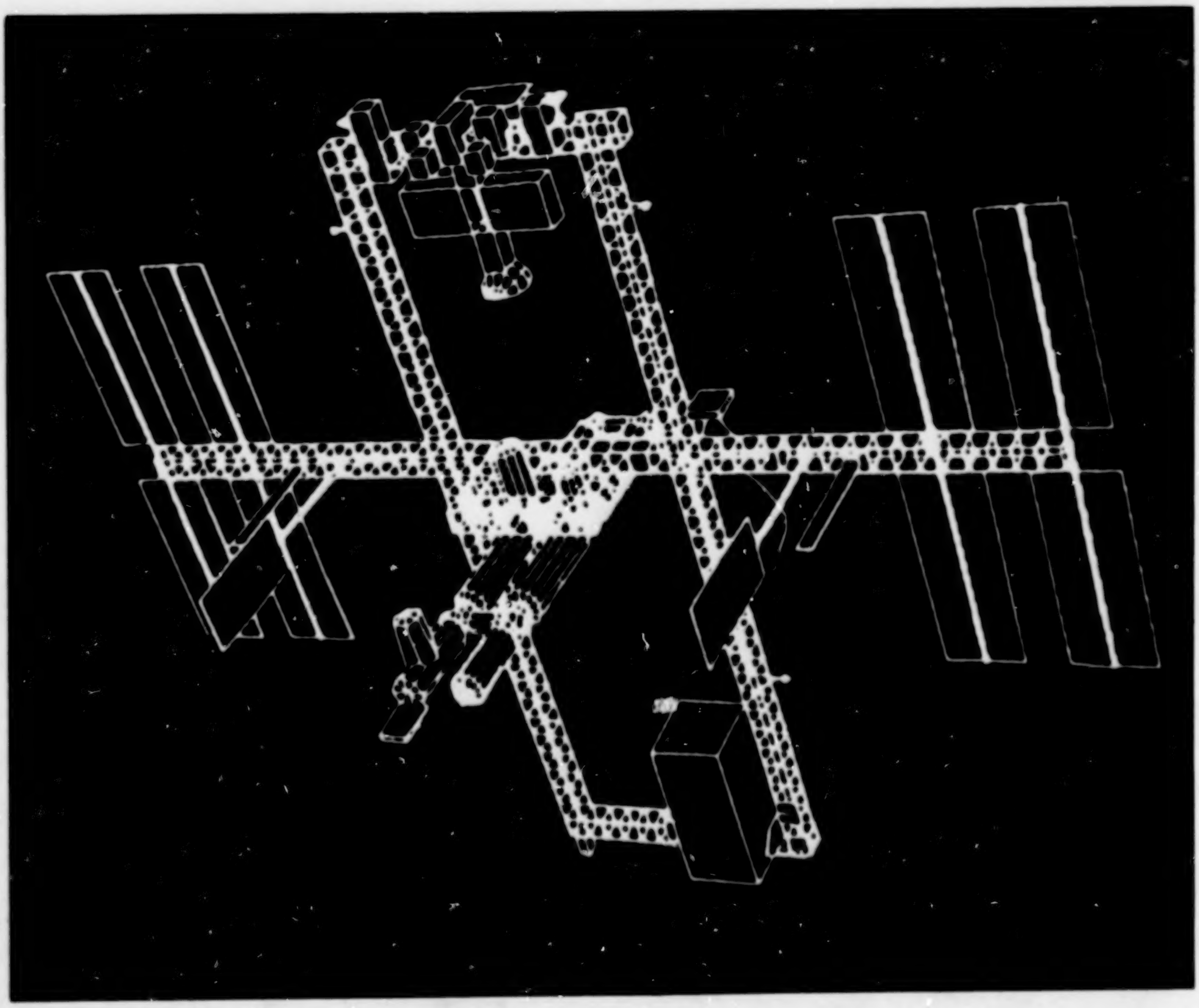

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NASA SP-7056(06)

SPACE STATION SYSTEMS

A BIBLIOGRAPHY
WITH INDEXES

Supplement 6

Compiled by
Technical Library Branch
and
Edited by
Space Station Office
NASA Langley Research Center
Hampton, Virginia

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between July 1 and December 31, 1987 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

Scientific and Technical Information Division 1988
National Aeronautics and Space Administration
Washington, DC

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Space Station Systems* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield , Virginia 22161 at the price code A13.

INTRODUCTION

This bibliography is designed to be helpful to the researchers, designers, and managers engaged in the design and development of technology, configurations, and procedures that enhance efficiencies of current and future versions of a Space Station.

This literature survey lists 1,133 reports, articles and other documents announced between July 1, 1987 and December 31, 1987 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future Space Station. In addition, analytical and experimental techniques and mathematical models required to investigate the different systems/subsystems and conduct trade studies of different configurations, designs, and scenarios are included. A general category completes the list of subjects addressed by this document.

The selected items are grouped into categories as listed in the Table of Contents with notes regarding the scope of each category. These categories were especially selected for this publication and differ from those normally found in *STAR* and *IAA*.

Each entry consists of a standard bibliographic citation accompanied by an abstract, where available, and appears with the original accession numbers from the respective announcement journals.

Under each of the categories, the entries are presented in one of two groups that appear in the following order:

(1) *IAA* entries identified by accession number series A87-10,000 in ascending accession number order;

(2) *STAR* entries identified by accession number series N87-10,000 in ascending accession number order.

After the abstract section there are seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number.

A companion continuing bibliography, *"Technology for Large Space Structures,"* is available as NASA SP-7046.

Robert E. Satterthwaite, *Space Station Office*
Sue K. Seward, *Technical Library Branch*

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TABLE OF CONTENTS

Page

Category 01 Systems 1

Includes system requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies; systems analyses for future required technology; and identification and description of technology developments and experiments for the elements of a complete Space Station system.

Category 02 Models, Analytical Design Techniques, and Environmental Data 5

Includes descriptions of computerized interactive systems design and development techniques, computer codes, internal and external environmental models and data.

Category 03 Structural Concepts 11

Includes analyses and descriptions of different Space Station structural concepts, arrangements, testing, methods of construction and/or manufacturing and specific rotary joints, structural nodes, and columns.

Category 04 Thermal Control 40

Includes descriptions of analytical techniques, passive and active thermal control techniques, external and internal thermal experiments and analyses and trade studies of thermal requirements.

Category 05 Environmental Control and Life Support Systems 46

Includes description of analytical techniques and models, trade studies of technologies, subsystems, support strategies, and experiments for internal and external environmental control and protection, life support systems, human factors, life sciences and safety.

Category 06 Dynamics and Controls 54

Includes descriptions of analytical techniques and computer codes, trade studies, requirements and decriptions of orbit maintenance systems, rigid and flexible body attitude sensing systems and controls such as momentum wheels and/or propulsive schemes.

Category 07 Power 74

Includes descriptions of analyses, systems, and trade studies of electric power generation, storage, conditioning and distribution.

Category 08 Electronics 84

Includes descriptions of analytical techniques, analyses, systems, and requirements for internal and external communications, electronics, sensors for position and systems monitoring and antennas.

Category 09 Propulsion/Fluid Management 88

Includes descriptions, analyses, and subsystem requirements for propellant/fluid management, and propulsion systems for attitude control and orbit maintenance and transfer for the station and supporting elements such as the OMV and OTV.

Category 10 Mechanisms, Automation, and Artificial Intelligence 99

Includes descriptions of simulations, models, analytical techniques, and requirements for remote, automated and robotic mechanical systems.

Category 11 Materials 105

Includes mechanical properties of materials, and descriptions and analyses of different structural materials, films, coatings, bonding materials, and descriptions of the effects of natural and induced space environments.

Category 12 Information and Data Management 111

Includes descriptions, requirements, and trade studies of different information and data system hardware and software, languages, architecture, processing and storage requirements for managing and monitoring of different systems and subsystems.

Category 13 Accommodations 118

Includes descriptions of simulations, analyses, trade studies, and requirements for safe efficient procedures, facilities, and support equipment on the ground and in space for processing, servicing, verification and checkput of cargo and equipment.

Category 14 Growth 120

Includes descriptions of scenarios, analyses and system technology requirements for the evolutionary growth of the Space Station system.

Category 15 Missions, Tethers, and Platforms 121

Includes descriptions and requirements of missions and tethers onboard the Space Station and platforms that are either co-orbiting with the Space Station, in polar orbit, or in geosynchronous orbit and which are part of the Space Station system.

Category 16 Operations Support 132

Includes descriptions of models, analyses and trade studies of maneuvers, performance, support, and EVA and/or IVA servicing requirements of Space Station systems such as the OMV and OTV, and experiments.

Category 17 Space Environment 138

Includes description of the space environment and effects on Space Station subsystems. Includes requirements of Space Station to accommodate this environment.

Category 18 International 143

Includes descriptions, interfaces and requirements of international payload systems, subsystems and modules considered part of the Space Station system and other international Space Station activities such as the Soviet Salyut.

Category 19 Support Spacecraft 160

Includes design, analysis, requirements, trade studies and simulations of Space Station support spacecraft including the orbital transfer vehicle (OTV) and the orbital maneuvering vehicle (OMV).

Catefory 20 Life Sciences/Human Factors/Safety 162

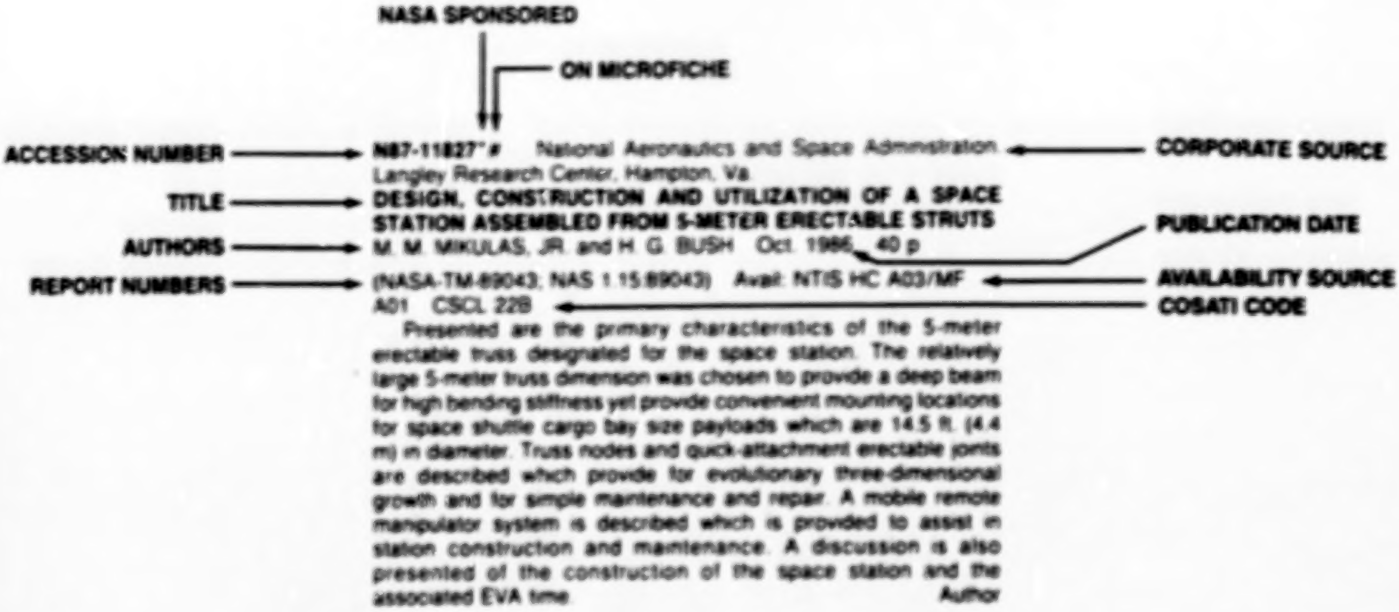
Includes studies, models, planning, analyses and simulations for biological and medical laboratories, habitability issues for the performance and well-being of the crew, and crew rescue.

Category 21 General 166

Includes descriptions, analyses, trade studies, commercial opportunities, published proceedings, seminars, hearings, historical summaries, policy speeches and statements that have not previously been included.

Subject Index A-1 173
Personal Author Index B-1 230
Corporate Source Index C-1 258
Foreign Technology Index D-1 268
Contract Number Index E-1 272
Report Number Index F-1 274
Accession Number Index G-1 278

TYPICAL REPORT CITATION AND ABSTRACT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N87-11827*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

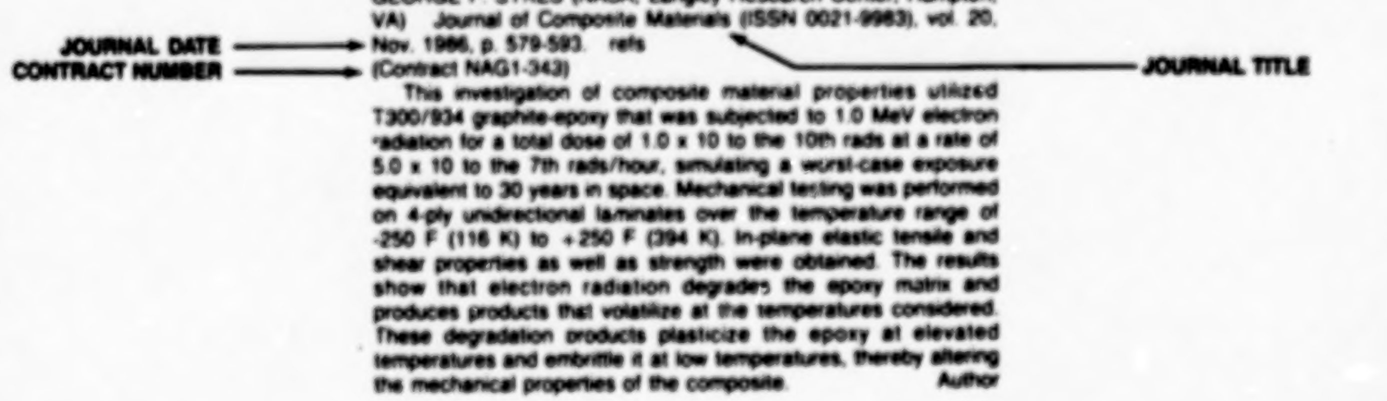
DESIGN, CONSTRUCTION AND UTILIZATION OF A SPACE STATION ASSEMBLED FROM 5-METER ERECTABLE STRUTS

M. M. MIKULAS, JR. and H. G. BUSH Oct. 1986 40 p

(NASA-TM-89043; NAS 1.15:89043) Avail: NTIS HC A03/MF A01 CSCL 22B

Presented are the primary characteristics of the 5-meter erectable truss designated for the space station. The relatively large 5-meter truss dimension was chosen to provide a deep beam for high bending stiffness yet provide convenient mounting locations for space shuttle cargo bay size payloads which are 14.5 ft. (4.4 m) in diameter. Truss nodes and quick-attachment erectable joints are described which provide for evolutionary three-dimensional growth and for simple maintenance and repair. A mobile remote manipulator system is described which is provided to assist in station construction and maintenance. A discussion is also presented of the construction of the space station and the associated EVA time. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT


NASA SPONSORED
ACCESSION NUMBER
TITLE
AUTHORS
JOURNAL DATE
CONTRACT NUMBER
AUTHOR'S AFFILIATION
JOURNAL TITLE

A87-27178* Virginia Polytechnic Inst. and State Univ., Blacksburg.

SPACE RADIATION EFFECTS ON THE THERMO-MECHANICAL BEHAVIOR OF GRAPHITE-EPOXY COMPOSITES

SCOTT M. MILKOVICH, CARL T. HERAKOVICH (Virginia Polytechnic Institute and State University, Blacksburg), and GEORGE F. SYKES (NASA, Langley Research Center, Hampton, VA) Journal of Composite Materials (ISSN 0021-9983), vol. 20, Nov. 1986, p. 579-593. refs

(Contract NAG1-343)

This investigation of composite material properties utilized T300/934 graphite-epoxy that was subjected to 1.0 MeV electron radiation for a total dose of 1.0 x 10 to the 10th rads at a rate of 5.0 x 10 to the 7th rads/hour, simulating a worst-case exposure equivalent to 30 years in space. Mechanical testing was performed on 4-ply unidirectional laminates over the temperature range of -250 F (116 K) to +250 F (394 K). In-plane elastic tensile and shear properties as well as strength were obtained. The results show that electron radiation degrades the epoxy matrix and produces products that volatilize at the temperatures considered. These degradation products plasticize the epoxy at elevated temperatures and embrittle it at low temperatures, thereby altering the mechanical properties of the composite. Author

SPACE STATION SYSTEMS

A Bibliography (Suppl. 6)

JULY 1988

01

SYSTEMS

Includes system requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies; systems analyses for future required technology; and identification and description of technology developments and experiments for the elements of a complete Space Station system.

A87-32116
A QUESTION OF GRAVITY
RAY SPANGENBURG and DIANE MOSER Space World (ISSN 0038-6332), vol. X-2-278, Feb. 1987, p. 8-11.

Artificial gravity is the only currently known method for avoiding the physiological effects of long-term weightlessness which Space Station and Mars mission crew would encounter. Techniques such as exercise and lower body negative pressure devices have not proven sufficiently effective. Vestibular excitement by the Coriolis force rules out use of a rotating room that could be contained in spaceships. A leading alternative for a Mars mission is to have a nuclear reactor tethered to a spacecraft a kilometer away. The entire configuration would rotate about its center, providing artificial gravity and minimizing the Coriolis force at the populated end. Ground-based bedrest and rotating room and proposed Space Station co-orbiting variable gravity experiments which may determine the minimal artificial gravity needed to avoid the effects of prolonged weightlessness are summarized. M.S.K.

A87-32277* National Aeronautics and Space Administration, Washington, D.C.
NASA'S SPACE PROGRAM - SPACE STATION: A STATUS REPORT AND A VIEW OF ITS VALUE FOR SPACE SCIENCE
DAVID C. BLACK (NASA, Office of Space Station, Washington, DC) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 3-6.

The current status of the Space Station program and the proposed configuration, operation, and evolution of the Space Station are described. The Space Station is to be composed of a manned base and two unmanned platforms; the configuration of the Station is dual keel, and the baseline system includes a hybrid power system with photovoltaics providing 25 kW and solar dynamics providing 50 kW. International participation in the development and use of the Space Station, in particular the design of the pressurized modules, is discussed. Intended scientific uses of the Space Station Complex are considered. I.F.

A87-32625
COMMERCIAL US TRANSFER VEHICLE OVERVIEW
J. W. WINCHELL and R. L. HUSS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 13 p.
(SAE PAPER 861784)

A survey is presented of the design and operational status and intended or existing missions for apogee kick motors for launch from the Orbiter bay. Attention is also given to the associated hardware for interfacing and propelling the payloads from the bay. The PAM-D, -DII, and -A upper stage motors are described, with their payload boost capabilities of 1500-4300 lb to GEO. Features of the solid-fueled Transfer Orbit Stage, based on the IUS, and the liquid bipropellant-fueled Apogee and Maneuvering Stage, which can lift from 3000-5600 lb to GEO, respectively, are also delineated. The discussion also covers the liquid-fueled Leasat apogee motor, the solid-fueled GEO injection motor of the Shuttle Compatible Orbit Transfer Subsystem (4100-5900 lb), and the IUS (5000 lb) and Centaur (10,000 lb) systems. Government-industry cooperation to encourage the continued development of the industrial base to continue and expand production and use of upper stage vehicles is noted. M.S.K.

A87-32902
STABILITY IN THE RELATIVE EQUILIBRIUM POSITIONS OF SPACE STATIONS AT TRIANGULAR LIBRATION POINTS IN THE PHOTOGRAVITATIONAL THREE-BODY PROBLEM
A. A. PEREZHOGIN (Kosmicheskie Issledovaniia, vol. 23, Sept.-Oct. 1985, p. 676-683) Cosmic Research (ISSN 0010-9525), vol. 23, no. 5, March 1986, p. 528-533. Translation. refs

A study has been made regarding the selection of stable equilibrium orientations for a space station using solar sails for control and gravitational equilibrium for anchoring at specific points in space. The study considers the generalized, photogravitational, restricted, circular three-body problem. Passively gravitating space stations are modeled by solid objects. It is assumed that the sail area of the station (the ratio of cross section to mass) does not depend on the station's orientation. Two dynamically equivalent relative equilibrium positions for the station are found from the conditions of steady-state change in the station's potential energy. The sufficient conditions for stability of the equilibrium solutions are obtained. D.H.

A87-37963
SPACE SHUTTLE FLIGHT RATES AND UTILIZATION
Space Policy (ISSN 0265-9646), vol. 3, Feb. 1987, p. 5-9. Previously announced in STAR as N87-14366.

Possible space shuttle flight rates and their implications in respect to payloads and the need for expendable launch vehicles are assessed. B.G.

A87-40051
U.S. NATIONAL CONGRESS OF APPLIED MECHANICS, 10TH, UNIVERSITY OF TEXAS, AUSTIN, JUNE 16-20, 1986, PROCEEDINGS
J. PARKER LAMB, ED. (Texas, University, Austin) Congress organized by the National Academy of Sciences and National Academy of Engineering; Supported by NSF, U.S. Navy, Dow Chemical Co., et al. New York, American Society of Mechanical Engineers, 1987, 556 p. For individual items see A87-40052 to A87-40065.
(AD-A181962)

Recent advances in applied mechanics are addressed in reviews and reports of theoretical and experimental investigations. Topics examined include cellular biomechanics, computational fluid mechanics, continuum damage mechanics, dispersed systems, the dynamic stability of structures, experimental methods in mechanics, and fluid mechanics in material processing. Consideration is given to manufacturing processes, material modeling for fracture, the mechanics of particulate media, NDE, space structures, stability and the transition to turbulence, temporal and spatial chaos, and unsteady aerodynamics. T.K.

A87-40351

EASCON '86; PROCEEDINGS OF THE NINETEENTH ANNUAL ELECTRONICS AND AEROSPACE SYSTEMS CONFERENCE, WASHINGTON, DC, SEPT. 8-10, 1986

Conference sponsored by IEEE, Armed Forces Communications and Electronics Association, and National Space Club. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, 296 p. For individual items see A87-40352 to A87-40381.

Papers are presented on civilian space programs, military space programs, the status of the Space Station, and satellite communications in the fiber era. Topics discussed include remote sensing programs, Space Station communications and data management, communications satellite systems, and advanced software and microelectronics technology. Consideration is given to Space Station experiments, near-term science missions, communications technology, very small aperture terminals, future science missions, and avionics, robotic, and support technology. I.F.

A87-45523

ANTENNA SYSTEMS AND RF COVERAGE FOR THE SPACE STATION

Y. C. LOH, K. W. SHELTON, and K. TU (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 838-842.

This paper presents some of the results on the radio frequency (RF) coverage analysis of the Space Station (SS) to Tracking Data Relay Satellite System (TDRSS) links and the Multiple-Access (MA) links. The antenna systems for both types of communication links were identified by considering typical operational scenarios, different types of services needed, and the architecture of the communication system. The paper describes the obscuration analysis tools for the placement of the antennas and an optimization procedure used to design the MA near range antenna system. Author

A87-48801#

AUTOMATED SOFTWARE PRODUCTION

R. J. LAUBER (Stuttgart, Universitaet, West Germany) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 8 p. refs
(AIAA PAPER 87-2219)

The automation-based software paradigm which forms the basis of the EPOS system is discussed, and it is suggested that such a paradigm may alleviate many problems inherent in software systems such as the embedded software systems required for the Space Station. Automated code generation features are discussed using an Ada generator as an example. The need for automated software verification is emphasized, and various approaches to software verification and validation are considered. It is suggested that software reusability may be a powerful tool for improving reliability, as well as improving software productivity. R.R.

A87-53082* United Technologies Corp., East Hartford, Conn.

THE HUMAN QUEST IN SPACE; PROCEEDINGS OF THE TWENTY-FOURTH GODDARD MEMORIAL SYMPOSIUM, GREENBELT, MD, MAR. 20, 21, 1986

GERALD L. BURDETT, ED. (United Technologies Corp., Hartford, CT) and GERALD A. SOFFEN, ED. (NASA, Goddard Space Flight Center, Greenbelt, MD) Symposium organized by AAS; Sponsored by AAS, AIAA, National Space Club, and National Space Institute. San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 65), 1987, 310 p. For individual items see A87-53083 to A87-53093.

Papers are presented on the Space Station, materials processing in space, the status of space remote sensing, the evolution of space infrastructure, and the NASA Teacher Program. Topics discussed include visionary technologies, the effect of intelligent machines on space operations, future information technology, and the role of nuclear power in future space missions. Consideration is given to the role of humans in space exploration; medical problems associated with long-duration space flights; lunar and Martian settlements, and Biosphere II (the closed ecology project). I.F.

A87-53086

TECHNOLOGY PROJECTIONS AND SPACE SYSTEMS OPPORTUNITIES FOR THE 2000-2030 TIME PERIOD

ROBERT A. DAVIS (Aerospace Corp., Los Angeles, CA) IN: The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 75-120; Discussion, p. 121-123. refs
(AAS PAPER 86-109)

Some of the space system technologies necessary for civil space projects in the future (2000-2030), which were included in a report prepared for the American Institute of Aeronautics and Astronautics for submittal to the National Space Commission, are described. The effects of NASA and DOD space system technology planning, the SDI program, and National Space Strategy on space systems and technology developments are examined. Space transportation, the establishment of a Space Station, the role of government in space commercialization, international competition in space, joint space missions, and space activities for enhancing global habitability are discussed. Consideration is given to the benefits space systems with earth-oriented applications can provide to civilian communications, navigation and location, earth observation, and space manufacturing; missions to the moon, Mars, comets, asteroids, other planets, and the Galaxy; the next-generation of space transportation systems and mission control; and the construction and maintenance of space infrastructure. I.F.

N87-20356*# National Aeronautics and Space Administration, Washington, D.C. Materials and Structures Div.

FUTURE TRENDS IN SPACECRAFT DESIGN AND QUALIFICATION

SAMUEL L. VENNERI, BRANTLEY R. HANKS (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.), and LARRY D. PINSON *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 9 p Jul. 1986
Avail: NTIS HC A12/MF A01 CSCL 22A

Material and structures issues that must be resolved in order to develop the technology data base needed to design and qualify the next generation of large flexible spacecraft are discussed. This invoves the development of new ground test and analysis methods and the conduct of appropriate instrumented in-space flight experiments for final verification. A review of present understanding of material behavior in the space environment and identification of future needs is presented. The dynamic verification and subsequent qualification of a spacecraft structure currently rely heavily on ground-based tests, coupled with the verified analysis model. Future space structures, such as large antennas, Space Station and other large platforms, will be of sizes difficult to test using current ground test methods. In addition to size, other complex factors, such as low natural frequencies, lightweight construction and many structural joints, will also contribute significant problems to the test and qualification process in an Earth-gravity environment. These large spacecraft will also require new technology for controlling the configuration and dynamic deformations of the structures. Future trend in large flexible structures will also involve long-life design missions (10 to 20 years). In low earth orbit (LEO), materials will be subjected to repeated thermal cycles, ultraviolet radiation, atomic oxygen and vacuum. For high orbits such as geo-synchronous earth orbit (GEO), the materials will also be subjected to large doses of high energy electrons and protons. Understanding degradation and material stability over long-mission time periods will confront the designer with many issues that are unresolved today.

N87-20682*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AERO-ASSISTED ORBITAL TRANSFER VEHICLE (AOTV)
OLIVER HILL *In* NASA. Marshall Space Flight Center Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations p 203-219 Feb. 1987
Avail: NTIS HC A13/MF A01 CSCL 04A

The AOTV will make use of the atmosphere to provide braking on return from a planetary mission or geosynchronous orbit. The minimum altitude for aerobraking is typically 255,000 ft at the equator. Time of the braking maneuver is typically 480 sec from 400,000 ft to 255,000 ft and back out - about 8 min. The problem is to design a control system that will be able to handle density irregularities such as those that have shown up in shuttle data near 280,000 ft. To obtain data, one has to use model-produced statistics or information obtained during the atmospheric transit time. The Global Reference Atmosphere Model (GRAM) appears to bracket the shuttle data, but it is not clear that the statistics are correct. The model-data exhibits strong density shears over small step size that are probably an artifact. Author

N87-23680# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A SYSTEMS ANALYSIS OF EMERGENCY ESCAPE AND RECOVERY SYSTEMS FOR THE US SPACE STATION M.S. Thesis
BRIAN K. KELLY Dec. 1986 115 p
(AD-A178233; AFIT/GSO/AA/86D-5) Avail: NTIS HC A06/MF A01 CSCL 06G

Recent designs for the U.S. manned space station have crews on board the space station without any means of emergency escape for periods of up to 90 days. This investigation analyzes emergency escape recovery systems for use on the space station in an effort to find the best escape device. Initially, the objectives to be met by an effective escape device were identified along with the corresponding measures of effectiveness (MOE) for each objective. Fifteen alternative escape systems were found that could be used on the manned core portion of the space station complex. A preliminary analysis reduced the number of alternatives considered for more detailed analysis to six. These final six, The Maneuverable Entry Research Vehicle (MERV), Emergency Astronaut Re-entry Parachute System, Manned Orbital Escape System (MOSES), MOOSE (Man out of Space Easiest), and Apollo Command Module, were compared on the basis of their calculated MOEs using multi-attribute utility theory. The overall utilities for each of the final six alternatives were calculated for two crew sizes, 3-man and 8-man. MOSES was found to consistently rate the highest overall utility for both manning scenarios. The next best alternative was the Apollo Command Module. GRA

N87-24500*# National Aeronautics and Space Administration, Washington, D.C.
LARGE SPACE SYSTEMS TECHNOLOGY AND REQUIREMENTS
JAMES M. ROMERO *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 665-673 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

Only viewgraphs of this presentation are shown. Outlined are NASA's space emphasis, state of technology, space R&D funding trend and civil space technology initiative. Also given are Control/Structures Interaction Technology (CSTI) focus, program focus on driver missions, in-space technology experiments, and in-space R&T approach. E.R.

N87-20083*# General Electric Co., Philadelphia, Pa. Re-Entry Systems Operations.
SYSTEM TECHNOLOGY ANALYSIS OF AEROASSISTED ORBITAL TRANSFER VEHICLES. MODERATE LIFT/DRAG (0.75-1.5): VOLUME 1A, PART 2: EXECUTIVE SUMMARY, PHASE 2 Final Report
Aug. 1985 33 p
(Contract NAS8-35096)
(NASA-CR-179140; NAS 1.26:179140; REPT-85SDS2184-VOL-1A-PT-2) Avail: NTIS HC A03/MF A01 CSCL 22A

Significant achievements and activities of Phase 2 of a study to assess aeroassisted orbit transfer vehicle (AOTV) system technology are summarized. Phase 2 was directed towards identification and prioritization of technology payoffs of representative space based mid lift/drag ratio (L/D) AOTV's and the cryofueled propulsion subsystem - configuration interactions. Enhancing technology areas were identified which could provide substantial transport cost reduction. These include: (1) improved lifetime of storable propellant engines; (2) avionics weight reduction; (3) external thermal protection system weight reduction; (4) decrease of uncertainties in aerodynamic and aerothermodynamic performance; electrical power subsystem weight reduction due to incorporation of advanced materials; and (6) structural shell weight reduction. Results indicated that advanced aerothermodynamic methodology and aft end configuring may provide an enlarged allowable zone for engine nozzle protrusions into the separated flow region. Payload manifesting and non-hydrogen propellant manifesting at the space station is recommended. M.G.

N87-20084*# General Electric Co., Philadelphia, Pa. Re-Entry Systems Operations.
SYSTEM TECHNOLOGY ANALYSES OF AEROASSISTED ORBITAL TRANSFER VEHICLES: MODERATE LIFT/DRAG (0.75-1.5). VOLUME 3: COST ESTIMATES AND WORK BREAKDOWN STRUCTURE/DICTIONARY, PHASE 1 AND 2 Final Report
Aug. 1985 44 p
(Contract NAS8-35096)
(NASA-CR-179144; NAS 1.26:179144; REPT-85SDS2184-VOL-3) Avail: NTIS HC A03/MF A01 CSCL 22B

Technology payoffs of representative ground based (Phase 1) and space based (Phase 2) mid lift/drag ratio aeroassisted orbit transfer vehicles (AOTV) were assessed and prioritized. A narrative summary of the cost estimates and work breakdown structure/dictionary for both study phases is presented. Costs were estimated using the Grumman Space Programs Algorithm for Cost Estimating (SPACE) computer program and results are given for four AOTV configurations. The work breakdown structure follows the standard of the joint government/industry Space Systems Cost Analysis Group (SSCAG). A table is provided which shows cost estimates for each work breakdown structure element. M.G.

N87-20085*# General Electric Co., Philadelphia, Pa. Re-Entry Systems Operations.
SYSTEM TECHNOLOGY ANALYSIS OF AEROASSISTED ORBITAL TRANSFER VEHICLES: MODERATE LIFT/DRAG (0.75-1.5). VOLUME 2: SUPPORTING RESEARCH AND TECHNOLOGY REPORT, PHASE 1 AND 2 Final Report
Aug. 1985 41 p
(Contract NAS8-35096)
(NASA-CR-179143; NAS 1.26:179143; REPT-85SDS2184-VOL-2) Avail: NTIS HC A03/MF A01 CSCL 22B

Technology payoffs of representative ground based (Phase 1) and space based (Phase 2) mid lift/drag ratio (L/D) aeroassisted orbit transfer vehicles (AOTV) were assessed and prioritized. The methodology employed to generate technology payoffs, the major payoffs identified, the urgency of the technology effort required, and the technology plans suggested are summarized for both study phases. Technology issues concerning aerodynamics, aerothermodynamics, thermal protection, propulsion, and guidance, navigation and control are addressed. M.G.

N87-26066*# General Electric Co., Philadelphia, Pa. Re-Entry Systems Operations.
SYSTEM TECHNOLOGY ANALYSIS OF AEROASSISTED ORBITAL TRANSFER VEHICLES: MODERATE LIFT/DRAG (0.75-1.5),VOLUME 1B, PART 1, STUDY RESULTS Final Report
Aug. 1985 228 p
(Contract NAS8-35096)
(NASA-CR-179141; NAS 1.26:179141; REPORT-85SDS2184-VOL-1B-PT-1) Avail: NTIS HC A11/MF A01 CSCL 22B

Significant performance benefits can be realized via aerodynamic breaking and/or aerodynamic maneuvering on return from higher altitude orbits to low Earth orbit. This approach substantially reduces the mission propellant requirements by using the aerodynamic drag, D, to brake the vehicle to near circular velocity and the aerodynamic lift, L, to null out accumulated errors as well as change the orbital inclination to that required for rendezvous with the Space Shuttle Orbiter. A study was completed where broad concept evaluations were performed and the technology requirements and sensitivities for aeroassisted Orbital Transfer Vehicles (AOTVs) over a range of vehicle hypersonic L/D from 0.75 to 1.5 were systematically identified and assessed. The AOTV is capable of evolving from an initial delivery only system to one eventually capable of supporting manned roundtrip missions to geosynchronous orbit. Concept screenings were conducted on numerous configurations spanning the L/D = 0.75 to 1.5 range, and several with attractive features were identified. Initial payload capability was evaluated for a baseline of delivery to GEO, six hour polar, and Molniya orbits with return and recovery of the AOTV at LEO. Evolutionary payload requirements that were assessed include a GEO servicing mission and a manned GEO mission. Author

N87-26067*# General Electric Co., Philadelphia, Pa. Re-Entry Systems Operations.
SYSTEM TECHNOLOGY ANALYSIS OF AEROASSISTED ORBITAL TRANSFER VEHICLES: MODERATE LIFT/DRAG (0.75-1.5), VOLUME 1B, PART 2, STUDY RESULTS Final Report
Aug. 1985 250 p
(Contract NAS8-35096)
(NASA-CR-179142; NAS 1.26:179142; REPT-85SDS2184-VOL-1B-PT-2) Avail: NTIS HC A11/MF A01 CSCL 22B

A complete compilation of the results from Phase 2 of a study to identify and prioritize the technology payoffs of representative space based mid lift/drag ratio (L/D) aeroassisted orbit transfer vehicles (AOTV) and the cryofueled propulsion subsystem - configuration interactions is presented. Several combinations of basing and launch vehicle options, staging scenarios, missions (delivery, servicing, or manned round trip), and target orbits were considered. Space basing of an AOTV opens up numerous configuration opportunities. The size can exceed the launch vehicle cargo bay envelope by resorting to orbital assembly and the AOTV weight can exceed the launch vehicle capability. With the absence of fully fueled tanks during a ground based launch much lighter gossamer type structures are possible that may result in performance gains. At the Space Station, payload rearranging or manifesting may prove attractive. Several major conclusions regarding aerothermodynamics, aerodynamics, payload manifesting, the propulsion subsystem, and systems issues are discussed. M.G.

N87-26073* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 4)
May 1987 220 p
(NASA-SP-7056(04); NAS 1.21:7056(04)) Avail: NTIS HC A10 CSCL 22B

This bibliography lists 832 reports, articles, and other documents introduced into the NASA scientific and technical information system between July 1, 1986 and December 31, 1986. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future space station. Author

N87-26185*# Aerospace Corp., El Segundo, Calif.
LABORATORY STUDIES OF ATOMIC OXYGEN REACTIONS WITH SOLIDS Abstract Only
GRAHAM S. ARNOLD and DANIEL R. PEPLINSKI *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 103 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Atomic beam experiments were performed to investigate the rate of atomic oxygen etching of carbon and polyimide films. The main emphasis of these experiments was on gaining an understanding of the role of atomic oxygen translational energy and substrate temperature in promoting the reactions. The experimental facility and techniques are described and results reviewed. Author

N87-26583*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION INTEGRATED WALL DESIGN AND PENETRATION DAMAGE CONTROL. TASK 4: IMPACT DETECTION/LOCATION SYSTEM Final Report
J. M. NELSON and B. M. LEMPRIERE Jul. 1987 72 p
(Contract NAS8-36426)
(NASA-CR-179167; NAS 1.26:179167; D180-30550-3) Avail: NTIS HC A04/MF A01 CSCL 22B

A program to develop a methodology is documented for detecting and locating meteoroid and debris impacts and penetrations of a wall configuration currently specified for use on space station. Testing consisted of penetrating and non-penetrating hypervelocity impacts on single and dual plate test configurations, including a prototype 1.22 m x 2.44 m x 3.56 mm (4 ft x 8 ft x 0.140 in) aluminum waffle grid backwall with multilayer insulation and a 0.063-in shield. Acoustic data were gathered with transducers and associated data acquisition systems and stored for later analysis with a multichannel digitizer. Preliminary analysis of test data included sensor evaluation, impact repeatability, first waveform arrival, and Fourier spectral analysis. Author

N87-29163*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
USER DATA MANAGEMENT
In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 9 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

The primary objective is to identify, develop, and demonstrate key data management technologies to support user access to Space Station data. To accomplish this objective, there are several technical challenges which must be addressed. The first is how to provide routine customer access to high volume, dynamic and distributed data bases. This access will encompass the functions of mission and payload planning and operations, data processing and analysis, and data archive and distribution. Secondly, there must be some analysis of architectures for handling high volume data streams like those expected from the Space Station. This analysis will examine the use of packetized versus non-packetized data formats, modular expansion capabilities, real-time versus non-real-time data processing, and the interfaces and architecture required to support telescience operations. The task will also determine benchmarks of performance capabilities for technology operations, such as varied data base structures, data access procedures, distributed data base design, and data base machines. Information is provided here in outline form. Author

N87-29164*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ADVANCED SOFTWARE TOOLS SPACE STATION FOCUSED TECHNOLOGY

ROBERT W. NELSON *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 11 p Aug. 1985

Avail: NTIS HC A17/MF A01 CSCL 09B

Information is given in outline form on advanced software tools for the Space Station data management system. The Space Station data management system is identified as a highly distributed system with payload users controlling experiments and processing payload data from home facilities.

R.J.F.

N87-29563# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

DESIGN OF A MIXED FLEET TRANSPORTATION SYSTEM TO LOW EARTH ORBIT. VOLUME 1: EXECUTIVE SUMMARY. VOLUME 2: NEAR-TERM SHUTTLE REPLACEMENT. VOLUME 3: HEAVY-LIFT CARGO VEHICLE. VOLUME 4: ADVANCED TECHNOLOGY SHUTTLE REPLACEMENT

SUSAN T. FIELDS, KEVIN D. JOHNSON, THOMAS S. NICHOLS, MICHAEL J. NOVIN, PAUL J. SHAWCROSS, BARTON E. SHOWALTER, ELI NIEWOOD, comp., CHRIS YOUNG, comp., and CHRIS PETERSON, ed. and comp. 1987 852 p

Avail: NTIS HC A99/MF E03

The future of the American space program will depend on the development and choice of the next generation of launch vehicles. Future payloads may be too massive for the current Space Transportation System. Other missions may require the transportation of large crews of humans to the space station. Consequently, future launch vehicle fleets need to emphasize diversity and low cost. The design of four vehicles chosen to fulfill the future payload delivery requirements is discussed in general terms. An analysis of the cost and design of these vehicles will follow. This analysis will lead to a complete annual schedule of payload deliveries. Two different delivery programs are proposed: one strives for the lowest possible cost, and the other emphasizes the advancement of high technology in the space program.

Author

N87-29914*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE ELECTROCHEMICAL RESEARCH AND TECHNOLOGY (SERT)

Sep. 1987 364 p Conference held in Cleveland, Ohio, 14-16 Apr. 1987

(NASA-CP-2484; E-3506; NAS 1.55:2484) Avail: NTIS HC A16/MF A01 CSCL 10C

The conference provided a forum to assess critical needs and technologies for the NASA electrochemical energy conversion and storage program. It was aimed at providing guidance to NASA on the appropriate direction and emphasis of that program. A series of related overviews were presented in the areas of NASA advanced mission models (space stations, low and geosynchronous Earth orbit missions, planetary missions, and space transportation). Papers were presented and workshops conducted in a variety of technical areas, including advanced rechargeables, advanced concepts, critical physical electrochemical issues, and modeling.

N87-29916*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

LEO AND GEO MISSIONS

ENRICO MERCANTI *In* NASA-Lewis Research Center, Space Electrochemical Research and Technology (SERT) p 9-14 Sep. 1987

Avail: NTIS HC A16/MF A01 CSCL 22A

The occurrence of the Challenger disaster in early 1986 caused a severe reevaluation of the space program. Plans already established had to be drastically revised and new plans had to be made. NASA created the Space Leadership Planning Group (SLPG) to formulate space mission plans covering a 50 year period based on Agency goals and objectives responsive to the National Commission on Space recommendations. An interim view of the status of SLPG plans for low altitude and geosynchronous missions is presented.

Author

02

MODELS, ANALYTICAL DESIGN TECHNIQUES, AND ENVIRONMENTAL DATA

Includes descriptions of computerized interactive systems design and development techniques, computer codes, internal and external environmental models and data.

A87-29133

FREQUENCY DISPERSION IN THE ADMITTANCE OF THE POLYCRYSTALLINE CU2S/CDS SOLAR CELL

L. V. HMURCIK (Bridgeport, University, CT) and R. A. SERWAY (James Madison University, Harrisonburg, VA) Journal of Applied Physics (ISSN 0021-8979), vol. 61, Jan. 15, 1987, p. 756-761. Research supported by the University of Bridgeport. refs

The admittance versus frequency for the Cu2S/CdS solar cell was measured. In the dark, the dispersion fits a model of a simple Debye capacitor, with deviation due to grain-boundary scattering at low frequencies. Under illumination, the dispersion becomes a function of surface roughness. Modeled in fractal geometry, the admittance varies as (i x omega) exp m. A second term of this type occurs at high frequencies and at illuminations greater than 0.1 percent AM 1. In this case, the depletion layer extends deep into the CdS due to insufficient charge states at the interface.

Author

A87-32121* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

MAXIMUM LIKELIHOOD IDENTIFICATION USING AN ARRAY PROCESSOR

BANAVAR SRIDHAR (NASA, Ames Research Center, Moffett Field, CA) and JEAN-NOEL AUBRUN (Lockheed Research Laboratories, Palo Alto, CA) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Feb. 1987, p. 35-38. Research supported by the Lockheed Independent Research Program. refs

Maximum likelihood estimation (MLE) is a method used to calculate the parameters of a dynamic system. It can be applied to a large class of problems and has good statistical properties. The main disadvantage of the MLE method is the amount of computation required. This paper describes how the computation time can be reduced significantly by using an array processor. The estimation of the parameters of a dynamic model of the Space Station is used as an example to evaluate the method. Author

A87-33630

MOVER II - A COMPUTER PROGRAM FOR VERIFYING REDUCED-ORDER MODELS OF LARGE DYNAMIC SYSTEMS

J. D. CHROSTOWSKI and T. K. HASSELMAN (Engineering Mechanics Associates, Inc., Torrance, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 14 p. USAF-supported research. refs

(SAE PAPER 861790)

This paper introduces a computer code for model verification of linear dynamic systems. Presentation is made within the broader context of system identification, and the many alternatives available for implementing a code. Practical considerations of the system identification process are discussed first. Alternative methods are reviewed and a classification system for existing as well as nonexisting methods is proposed. Finally, a rationale for the selection of a particular modeling approach, type of measurement data, and estimation algorithm is discussed. Although MOVER II was not specifically designed for large space structures, its capabilities fulfill many of the needs now recognized as important in the verification of reduced-order models. Prior application involving extensive use of substructuring and coordinate reduction is discussed. Author

A87-32657* California Univ., Los Angeles.

INTEGRATED CONTROL/STRUCTURE DESIGN AND ROBUSTNESS

A. ADAMIAN and J. S. GIBSON (California, University, Los Angeles) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p. refs
(Contract JPL-957114)
(SAE PAPER 861821)

When a flexible structure is to be controlled actively, optimum performance is obtained by integrated, or simultaneous, design of the structure and the controller, as opposed to the common practice of designing the structure independently of control consideration and then designing a controller for a fixed structure. The primary design objective from the structural point of view usually is to minimize weight, while the control design objectives depend on the application. An important requirement for a practical control system is robustness with respect to uncertain plant parameters. This paper discusses simultaneous control/structure design when the overall design objective combines the weight of the structure and the robustness of the closed-loop control system. For numerical optimization, robustness is represented by the sensitivity of the closed-loop eigenvalues with respect to uncertain parameters. An example illustrates the optimal design of a flexible structure along with a robust compensator. Author

A87-33080

USER INTERFACE DESIGN GUIDELINES FOR EXPERT TROUBLESHOOTING SYSTEMS

DAVID R. EIKE, STEPHEN A. FLEGER, and ELIZABETH R. PHILLIPS (Carlow Associates, Inc., Fairfax, VA) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 1024-1028. refs

This paper describes the status and preliminary results of an ongoing research project to develop and validate user interface design guidelines for expert troubleshooting systems (ETS). The project is part of a larger research program to study the application of emerging user interface technologies to the design and development of user interfaces for Space Station-era systems. The project has two separate research thrusts. The first and central thrust is to develop and validate a set of human engineering guidelines for designing the user interface of an ETs. The second thrust is to design and implement an electronic data base to manage storage and retrieval of the guidelines. This paper discusses the human factors issues that are unique to the design of a user interface for an ETS. Author

A87-33557#

ASTROS - A MULTIDISCIPLINARY AUTOMATED STRUCTURAL DESIGN TOOL

D. J. NEILL, E. H. JOHNSON (Northrop Corp., Aircraft Div., Hawthorne, CA), and R. CANFIELD (USAF, Wright Aeronautical Laboratories, Wright-Patterson, AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 44-53. refs
(Contract F33615-83-C-3232)
(AIAA PAPER 87-0713)

ASTROS (Automated Structural Optimization System) is a multidisciplinary software system that can be used in the preliminary design of aerospace structures. The approach being taken in this ongoing development project is to blend proven engineering tools into an efficient unified system through the use of a specifically designed software environment. ASTROS has reached a stage of development at which significant test cases have been performed which demonstrate the power and versatility of the system. This paper first presents background information that motivates the development of this new system, followed by a discussion of the engineering technologies that have been integrated into ASTROS. Emphasis is placed on some of the more novel features, such as the treatment of flutter constraints and the linking of physical design variables. Insight into how the software environment has been applied to implement the multidisciplinary design features is then followed by two representative test cases. Author

A87-33560*# Old Dominion Univ., Norfolk, Va.

PRACTICAL IMPLEMENTATION OF AN ACCURATE METHOD FOR MULTILEVEL DESIGN SENSITIVITY ANALYSIS

DUC T. NGUYEN (Old Dominion University, Norfolk, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 75-87. NASA-supported research. refs
(AIAA PAPER 87-0718)

Solution techniques for handling large scale engineering optimization problems are reviewed. Potentials for practical applications as well as their limited capabilities are discussed. A new solution algorithm for design sensitivity is proposed. The algorithm is based upon the multilevel substructuring concept to be coupled with the adjoint method of sensitivity analysis. There are no approximations involved in the present algorithm except the usual approximations introduced due to the discretization of the finite element model. Results from the six- and thirty-bar planar truss problems show that the proposed multilevel scheme for sensitivity analysis is more effective (in terms of computer incore memory and the total CPU time) than a conventional (one level) scheme even on small problems. The new algorithm is expected to perform better for larger problems and its applications on the new generation of computer hardwares with 'parallel processing' capability is very promising. Author

A87-33561*# Auburn Univ., Ala.

ANALYTICAL SOLUTIONS FOR STATIC ELASTIC DEFORMATIONS OF WIRE ROPES

K. KUMAR and J. E. COCHRAN, JR. (Auburn University, AL) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 88-92. refs
(Contract NAG8-532)
(AIAA PAPER 87-0720)

This paper develops closed-form solutions for extension of twisted wire ropes subjected to axial forces for two different end conditions. The analytical results are compared with the corresponding numerical results obtained by Costello and Phillips. A close agreement between the two establishes validity of the analytical solutions. Finally, an expression for the effective rigidity modulus of the wire ropes is obtained in terms of the helix angle and the number of helical wires in the rope for each of the two end conditions. Author

A87-33665*# State Univ. of New York, Buffalo.

VIBRATION SUPPRESSION USING A CONSTRAINED RATE-FEEDBACK THRESHOLD CONTROL STRATEGY

D. C. ZIMMERMAN, D. J. INMAN (New York, State University, Buffalo), and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 125-134. NASA-supported research. refs
(Contract NGT-33-183-801; NSF MEA-83-51807;
AF-AFOSR-85-0220)
(AIAA PAPER 87-0741)

Quasi-closed form solutions are derived for the finite time, minimum force rate-feedback threshold controller to bring a system with or without known external disturbances back into an 'allowable' state manifold in finite time. The disturbances are assumed to be expandable in terms of Fourier series. The quasi-closed form solutions replace the solution of the two-point boundary value problem and definite integral constraints with the solution of algebraic equations and the calculation of matrix exponentials.

Examples demonstrate the threshold control technique and compare the quasi-closed form solutions with MACSYMA generated exact solutions (for small system order) and with the numerical solution of the two-point boundary value problem. Author

A87-33728*# Colorado Univ., Boulder.

EVALUATION OF CONSTRAINT STABILIZATION PROCEDURES FOR MULTIBODY DYNAMICAL SYSTEMS

K. C. PARK and J. C. CHIOU (Colorado, University, Boulder) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 769-773. refs
(Contract NAS1-17660)
(AIAA PAPER 87-0927)

Comparative numerical studies of four constraint treatment techniques for the simulation of general multibody dynamic systems are presented, and results are presented for the example of a classical crank mechanism and for a simplified version of the seven-link manipulator deployment problem. The staggered stabilization technique (Park, 1986) is found to yield improved accuracy and robustness over Baumgarte's (1972) technique, the singular decomposition technique (Walton and Steeves, 1969), and the penalty technique (Lotstedt, 1979). Furthermore, the staggered stabilization technique offers software modularity, and the only data each solution module needs to exchange with the other is a set of vectors plus a common module to generate the gradient matrix of the constraints, B. R.R.

A87-35718* Arizona State Univ., Tempe.

A HYBRID NONLINEAR PROGRAMMING METHOD FOR DESIGN OPTIMIZATION

S. D. RAJAN (Arizona State University, Tempe) Journal of Structural Mechanics (ISSN 0360-1218), vol. 14, no. 4, 1986, p. 455-474. refs
(Contract NAG3-580)

Solutions to engineering design problems formulated as nonlinear programming (NLP) problems usually require the use of more than one optimization technique. Moreover, the interaction between the user (analysis/synthesis) program and the NLP system can lead to interface, scaling, or convergence problems. An NLP solution system is presented that seeks to solve these problems by providing a programming system to ease the user-system interface. A simple set of rules is used to select an optimization technique or to switch from one technique to another in an attempt to detect, diagnose, and solve some potential problems. Numerical examples involving finite element based optimal design of space trusses and rotor bearing systems are used to illustrate the applicability of the proposed methodology. Author

A87-37135

STABILITY OF TIME VARYING LINEAR SYSTEMS

SHASHI K. SHRIVASTAVA and S. PRADEEP (Indian Institute of Science, Bangalore, India) IN: Space dynamics and celestial mechanics; Proceedings of the International Workshop, Delhi, India, Nov. 14-16, 1985 . Dordrecht, D. Reidel Publishing Co., 1986, p. 87-101. refs

The history and fundamental principles of stability theory are examined in an analytical review, and some recent results are presented. Topics addressed include the early history of stability theory, stability of linear and nonlinear constant-parameter systems, periodic systems, second-order equations, arbitrarily time-varying systems, the absolute stability problem, and the functional analytical approach. The authors' recent work on multidimensional linear time-varying systems such as large space structures is summarized, and the results for the damped Mathieu equation (Pradeep and Shrivastava, 1986) are shown to be superior (for some parameter ranges) to those obtained by Taylor and Narenda (1969) and Gunderson et al. (1974). T.K.

A87-37296* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

REAL-TIME SIMULATION FOR SPACE STATION

ROBERT H. ST. JOHN (NASA, Johnson Space Center, Houston, TX), GERARD J. MOORMAN, and BLAINE W. BROWN (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 383-398. refs

Development of a new Space Station simulation designed to provide long-term support to the Space Station Program is well under way. A description of the two Engineering Directorate simulation facilities, the Systems Engineering Simulator and the Shuttle Avionics Integration Laboratory, is presented. The function of each in support of the Space Shuttle Program is discussed, with emphasis on functions applicable to Space Station. The function of the Systems Engineering Simulator in Space Station development is described. Finally, a comprehensive and detailed description of the new Space Station simulation under development on the System Engineering Simulator is presented. Author

A87-41611*# Hughes Aircraft Co., Los Angeles, Calif.

MODELING OF ENVIRONMENTALLY INDUCED TRANSIENTS WITHIN SATELLITES

N. JOHN STEVENS, GORDON J. BARBAY, MICHAEL R. JONES, and R. VISWANATHAN (Hughes Aircraft Co., Los Angeles, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, May-June 1987, p. 257-263. refs
(Contract NAS3-23869)
(AIAA PAPER 85-0387)

A technique is described that allows an estimation of possible spacecraft charging hazards. This technique, called SCREENS (spacecraft response to environments of space), utilizes the NASA charging analyzer program (NASCAP) to estimate the electrical stress locations and the charge stored in the dielectric coatings due to spacecraft encounter with a geomagnetic substorm environment. This information can then be used to determine the response of the spacecraft electrical system to a surface discharge by means of lumped element models. The coupling into the electronics is assumed to be due to magnetic linkage from the transient currents flowing as a result of the discharge transient. The behavior of a spinning spacecraft encountering a severe substorm is predicted using this technique. It is found that systems are potentially vulnerable to upset if transient signals enter through the ground lines. Author

A87-48602#

MISSION SCHEDULING EXPERT SYSTEM AND ITS SPACE STATION APPLICATIONS

T. YOSHIOKA (National Space Development Agency of Japan, Tokyo), T. KATO, T. WAKAKI, M. HORIO (Fujitsu, Ltd., Tokyo, Japan), N. SAKAMOTO (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) et al. AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 10 p.
(AIAA PAPER 87-2221)

Japan has joined the United States Space Station program with its unique Japanese Experiment Module development scheme. This paper describes the mission scheduling expert system designed to prepare plans of these experiments (missions), and explains its operation. A prototype of the mission scheduling expert system has recently been developed . Evaluation of the prototype has demonstrated that the system should be able to prepare an objective mission operation plan (especially a medium-short term plan or a short term plan). The scheduling conditions for this prototype, as well as its functions, scheduling algorithms and heuristic knowledge, performance evaluation results, and subjects for further study are also described in detail. Author

A87-50412*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ON THE INADEQUACIES OF CURRENT MULTI-FLEXIBLE BODY SIMULATION CODES

FIDELIS O. EKE and ROBERT A. LASKIN (California Institute of

Technology, Jet Propulsion Laboratory, Pasadena) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 79-89. refs
(AIAA PAPER 87-2248)

DISCOS was used to simulate the spin-up of a uniform flexible beam mounted on a rigid spinning disk. The system operated well for the first few seconds but then there was a drastic rise in deflection as the whole system became unstable. Attention is given to the reason for the breakdown of DISCOS and how this affects the simulation results from DISCOS and other multiflexible-body simulation programs. It is found that a formulation option already available in DISCOS will eliminate the dramatic divergence observed in high spin regimes and give good results in low spin regimes while requiring highly simplified input data. K.K.

N87-20373# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany). Abteilung Maschinenbau und Fahrzeuge.

MULTI-AXIS VIBRATION TESTS ON SPACECRAFT USING HYDRAULIC EXCITERS

H. HAHN and W. RAASCH *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 23 p Jul. 1986
Avail: NTIS HC A12/MF A01

Based on performance data that are specified for a spacecraft multi-axis hydraulic vibration test facility by ESA the feasibility of such a test facility is investigated. Technical problems and possible solutions concerning test table stiffness, elasticity of actuator oil column, actuator joints and oil consumption are discussed. More sophisticated problems may arise concerning the control and safety systems. The designed solutions include controllers for each individual actuator, controllers for a coordinated control of the multiple actuator system and a safety and monitoring system. The control system has to be based on a control strategy using a combination of analog fixed algorithm controllers and a digital variable algorithm controller both together performimg individual degree of freedom control including suitable decoupling procedures. The safety system has to be based on a triple redundancy concept for critical system components. It is recommended to built it by a digital multi-processor system. The investigations lead to the statement that multi-axis vibration tests of spacecrafts are realizable with respect to the necessary test equipment. Author

N87-20581*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MODAL TEST AND ANALYSIS: MULTIPLE TESTS CONCEPT FOR IMPROVED VALIDATION OF LARGE SPACE STRUCTURE MATHEMATICAL MODELS

B. K. WADA, C-P. KUO, and R. J. GLASER *In* Shock and Vibration Information Center The Shock and Vibration Bulletin. Part 2: Modal Test and Analysis, Testing Techniques, Machinery Dynamics, Isolation and Damping, Structural Dynamics p 1-8 Aug. 1986
Avail: NTIS HC A10/MF A01 CSCL 22B

For the structural dynamic analysis of large space structures, the technology in structural synthesis and the development of structural analysis software have increased the capability to predict the dynamic characteristics of the structural system. The various subsystems which comprise the system are represented by various displacement functions; the displacement functions are then combined to represent the total structure. Experience has indicated that even when subsystem mathematical models are verified by test, the mathematical representations of the total system are often in error because the mathematical model of the structural elements which are significant when loads are applied at the interconnection points are not adequately verified by test. A multiple test concept, based upon the Multiple Boundary Condition Test (MBCT), is presented which will increase the accuracy of the system mathematical model by improving the subsystem test and test/analysis correlation procedure. Author

N87-21020*# Engineering, Inc., Hampton, Va.

THE RESULTS OF A LIMITED STUDY OF APPROACHES TO THE DESIGN, FABRICATION, AND TESTING OF A DYNAMIC MODEL OF THE NASA IOC SPACE STATION. EXECUTIVE SUMMARY

GEORGE W. BROOKS Aug. 1985 150 p
(Contract NAS1-16610)
(NASA-CR-178276; NAS 1.26:178276; EI-278-R518) Avail: NTIS HC A07/MF A01 CSCL 22B

The options for the design, construction, and testing of a dynamic model of the space station were evaluated. Since the definition of the space station structure is still evolving, the Initial Operating Capacity (IOC) reference configuration was used as the general guideline. The results of the studies treat: general considerations of the need for and use of a dynamic model; factors which deal with the model design and construction; and a proposed system for supporting the dynamic model in the planned Large Spacecraft Laboratory. Author

N87-21154*# Battelle Pacific Northwest Labs., Richland, Wash.

TWO-PHASE REDUCED GRAVITY EXPERIMENTS FOR A SPACE REACTOR DESIGN

ZENEN I. ANTONIAK *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 163-169 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

Future space missions researchers envision using large nuclear reactors with either a single or a two-phase alkali-metal working fluid. The design and analysis of such reactors require state-of-the-art computer codes that can properly treat alkali-metal flow and heat transfer in a reduced-gravity environment. New flow regime maps, models, and correlations are required if the codes are to be successfully applied to reduced-gravity flow and heat transfer. General plans are put forth for the reduced-gravity experiments which will have to be performed, at NASA facilities, with benign fluids. Data from the reduced-gravity experiments with innocuous fluids are to be combined with normal gravity data from two-phase alkali-metal experiments. Because these reduced-gravity experiments will be very basic, and will employ small test loops of simple geometry, a large measure of commonality exists between them and experiments planned by other organizations. It is recommended that a committee be formed to coordinate all ongoing and planned reduced gravity flow experiments. Author

N87-21661* National Aeronautics and Space Administration. Pasadena Office, Calif.

VARIABLE ENERGY, HIGH FLUX, GROUND-STATE ATOMIC OXYGEN SOURCE Patent

ARA CHUTJIAN, inventor (to NASA) (Jet Propulsion Lab., California Inst. of Tech., Pasadena) and OTTO J. ORIENT, inventor (to NASA) 10 Mar. 1987 12 p Filed 10 Apr. 1986 Supersedes N86-27055 (24 - 17, p 2809)
(NASA-CASE-NPO-16640-1-CU; US-PATENT-4,649,273; US-PATENT-APPL-SN-852468; US-PATENT-CLASS-250-251; US-PATENT-CLASS-250-396-R; US-PATENT-CLASS-250-423-P; US-PATENT-CLASS-376-127) Avail: US Patent and Trademark Office CSCL 20H

A variable energy, high flux atomic oxygen source is described which is comprised of a means for producing a high density beam of molecules which will emit O(-) ions when bombarded with electrons; a means of producing a high current stream of electrons at a low energy level passing through the high density beam of molecules to produce a combined stream of electrons and O(-) ions; means for accelerating the combined stream to a desired energy level; means for producing an intense magnetic field to confine the electrons and O(-) ions; means for directing a multiple pass laser beam through the combined stream to strip off the excess electrons from a plurality of the O(-) ions to produce ground-state O atoms within the combined stream; electrostatic deflection means for deflecting the path of the O(-) ions and the electrons in the combined stream; and, means for stopping the O(-) ions and the electrons and for allowing only the ground-state O atoms to continue as the source of the atoms of interest. The

method and apparatus are also adaptable for producing other ground-state atoms and/or molecules.
Official Gazette of the U.S. Patent and Trademark Office

N87-21995*# General Electric Co., Philadelphia, Pa. Astro-Space Div.

THE MULTI-DISCIPLINARY DESIGN STUDY. A LIFE CYCLE COST ALGORITHM

R. R. HARDING, J. M. DURAN, and R. R. KAUFFMAN May 1987 107 p
(Contract NAS1-18032)
(NASA-CR-178192; NAS 1.26:178192; GE-DOC-87SDS-024)
Avail: NTIS HC A06/MF A01 CSCL 22B

Life-cycle cost (LCC) is investigated as a comprehensive design criterion for two major interrelated spacecraft subsystems, Controls and Structures. A Multi-Disciplinary Design Tool (MDDT) is developed to evaluate the sensitivity of LCC to subsystem design parameters. Major costs addressed are: non-recurring; launch; ground support; maintenance; expendables; and software. Examples and results from the MDDT are described, including a structural optimization study between different truss designs; a solar array feathering trade for a minimal drag configuration during umbra; and the cost of active control of a flexible structure is compared against the cost of passive damping using visco-elastic material. Author

N87-22711*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CONSIDERATIONS IN THE DESIGN AND DEVELOPMENT OF A SPACE STATION SCALE MODEL

PAUL E. MCGOWAN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 215-246 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

Preliminary work at Langley Research Center (LaRC) related to the design, analysis and testing of a space station scale model is reviewed. Included are some rationale for focusing the scale model program on space station and the utilization of the model to achieve the program objectives. In addition, some considerations involved in designing a dynamics scale model, such as ground test facilities, sub-scale component fabrication and model replication vs. simulation are presented. Finally, some related research areas currently ongoing at LaRC in support of scale model development are discussed. Author

N87-22716*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

COMMIT YOUR WORKS TO THE LORD, AND YOUR THOUGHTS SHALL BE ESTABLISHED (PROV. 16:3). INTER-STABLE CONTROL SYSTEMS

GEORGE L. VONPRAGENAU *In its* Structural Dynamics and Control Interaction of Flexible Structures p 335-358 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

Algebraic structures are discussed for control systems that maintain stability in the presence of resonance uncertainties. Dual algebraic operations serve as elementary connections that propagate the stability of inter-stable subsystems. Frequency responses within complex half-planes define different types of inter-stability. Dominance between incompatible types is discussed. Inter-stability produces sufficient but unnecessary stability conditions, except for conservative systems where the conditions become also necessary. Multivariable systems, colocation of actuator and sensor, and virtual colocation are treated. Instead of passivity, inter-stability relates stability to the mapping of poles and zeros by transfer functions and transfer matrices. Inter-stability determines stability on the subsystem level, is less complex even for multivariable systems, adds design flexibility, and relaxes the dynamic data problem of large systems such as space stations. Author

N87-22721*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.

STRUCTURAL/CONTROL INTERACTION (PAYLOAD POINTING AND MICRO-G)

C. R. LARSON *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 457-484 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

A 203rd order simulation model was developed to evaluate the space station customer accommodation payload pointing and micro-g requirements. The simulation shows the pointing errors on the telescope are significantly smaller than at the base of the telescope. The pointing results could change when the parametric studies are performed. The results show the micro-g requirement is met with an active isolation system. Author

N87-22735*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A TREETOPS SIMULATION OF THE HUBBLE SPACE TELESCOPE-HIGH GAIN ANTENNA INTERACTION

JOHN P. SHARKEY *In its* Structural Dynamics and Control Interaction of Flexible Structures p 881-902 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

Virtually any project dealing with the control of a Large Space Structure (LSS) will involve some level of verification by digital computer simulation. While the Hubble Space Telescope might not normally be included in a discussion of LSS, it is presented to highlight a recently developed simulation and analysis program named TREETOPS. TREETOPS provides digital simulation, linearization, and control system interaction of flexible, multibody spacecraft which admit to a point-connected tree topology. The HST application of TREETOPS is intended to familiarize the LSS community with TREETOPS by presenting a user perspective of its key features. B.G.

N87-22741*# Harris Corp., Melbourne, Fla. Government Aerospace Systems Div.

MAXIMUM ENTROPY/OPTIMAL PROJECTION (MEOP) CONTROL DESIGN SYNTHESIS: OPTIMAL QUANTIFICATION OF THE MAJOR DESIGN TRADEOFFS

D. C. HYLAND and D. S. BERNSTEIN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1033-1070 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The underlying philosophy and motivation of the optimal projection/maximum entropy (OP/ME) stochastic modeling and reduced control design methodology for high order systems with parameter uncertainties are discussed. The OP/ME design equations for reduced-order dynamic compensation including the effect of parameter uncertainties are reviewed. The application of the methodology to several Large Space Structures (LSS) problems of representative complexity is illustrated. B.G.

N87-23157*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

TAE PLUS: A CONCEPTUAL VIEW OF TAE IN THE SPACE STATION ERA

MARTHA SZCZUR *In its* Sixth Annual Users' Conference p 19-30 Oct. 1986
Avail: NTIS HC A11/MF A01 CSCL 09B

The use of the Transportable Applications Executive (TAE) for prototyping user interfaces has been the prime force behind the new TAE research and development work. The Data Systems Technology Division at GSFC is developing prototypes of user interfaces for different functions involved in the operation, analysis and data communication of space station payloads. TAE is a valuable prototyping tool because it enables a developer to build an entire application user interface model and run it without writing a single line of application code. One force driving new development is the need to update TAE's user interface to support the latest interactive graphic device technology. The current TAE, TAE Classic, uses interface techniques designed for an 80x24 character monochrome alphanumeric terminal, but does not effectively utilize features such as windowing, graphics, color, and selection devices available on newer workstations. To meet our needs, development of a TAE Plus began in FY-86 and involves augmenting TAE with three different sets of tools: a user interface toolkit; an application toolkit; and run-time service subroutines. A phased approach is being used to develop TAE Plus. In the first phase, we have met the needs of the user community and provided some support for rapid prototyping by developing a TAE Facelift, which adds an enhanced TAE interface (with windowing, mouse interaction, pull-down menus, etc.) to a select set of graphic workstations. The TAE Facelift allows many new concepts to be tested quickly for feedback and performance. In the second phase, a fully-integrated user interface management system, TAE Plus, will be built that supports the separation of interface from application, with the concomitant ability to prototype and rapidly change interfaces. This robust functionality will support, in an integrated manner, an application's development cycle from the prototype step through to the fully operational system. M.G.

N87-24709*# Edighoffer, Inc., Newport News, Va.
DYNAMIC AND THERMAL RESPONSE FINITE ELEMENT MODELS OF MULTI-BODY SPACE STRUCTURAL CONFIGURATIONS Final Report
HAROLD H. EDIGHOFFER Apr. 1987 156 p
(Contract NAS1-17210)
(NASA-CR-178289; NAS 1.26:178289) Avail: NTIS HC A08/MF A01 CSCL 20K

Presented is structural dynamics modeling of two multibody space structural configurations. The first configuration is a generic space station model of a cylindrical habitation module, two solar array panels, radiator panel, and central connecting tube. The second is a 15-m hoop-column antenna. Discussed is the special joint elimination sequence used for these large finite element models, so that eigenvalues could be extracted. The generic space station model aided test configuration design and analysis/test data correlation. The model consisted of six finite element models, one of each substructure and one of all substructures as a system. Static analysis and tests at the substructure level fine-tuned the finite element models. The 15-m hoop-column antenna is a truss column and structural ring interconnected with tension stabilizing cables. To the cables, pretensioned mesh membrane elements were attached to form four parabolic shaped antennae, one per quadrant. Imposing thermal preloads in the cables and mesh elements produced pretension in the finite element model. Thermal preload variation in the 96 control cables was adjusted to maintain antenna shape within the required tolerance and to give pointing accuracy. Author

N87-26205*# Lockheed Missiles and Space Co., Palo Alto, Calif.
SPACECRAFT RAM GLOW AND SURFACE TEMPERATURE Abstract Only
G. R. SWENSON, S. B. MENDE, and E. J. LLEWELLYN (Saskatchewan Univ., Saskatoon.) *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 169 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 22B

Space shuttle glow intensity measurements show large differences when the data from different missions are compared. In particular, on the 41-G mission the space shuttle ram glow was observed to display an unusually low intensity. Subsequent investigation of this measurement and earlier measurements suggest that there was a significant difference in temperature of the glow producing ram surfaces. The highly insulating properties coupled with the high emissivity of the shuttle tile results in surfaces that cool quickly when exposed to deep space on the night side of the orbit. The increased glow intensity is consistent with the hypothesis that the glow is emitted from excited NO2. The excited NO2 is likely formed through three body recombination (OI + NO + M = NO2*) where ramming of OI interacts with weakly surface bound NO. The NO is formed from atmospheric OI and NI which is scavenged by the spacecraft moving through the atmosphere. It is postulated that the colder surfaces retain a thicker layer of NO thereby increasing the probability of the reaction. It has been found from the glow intensity/temperature data that the bond energy of the surface bound precursor, leading to the chemical recombination producing the glow, is approximately 0.14 eV. A thermal analysis of material samples of STS-8 was made and the postulated temperature change of individual material samples prior to the time of glow measurements above respective samples are consistent with the thermal effect on glow found for the orbiter surface. Author

N87-27412*# Illinois Univ., Urbana. Dept. of Computer Science.
SAGA: A PROJECT TO AUTOMATE THE MANAGEMENT OF SOFTWARE PRODUCTION SYSTEMS Mid-Year Report, 1986
ROY H. CAMPBELL, C. S. BECKMAN-DAVIES, L. BENZINGER, G. BESHERS, D. LALIBERTE, H. RENDER, R. SUM, W. SMITH, and R. TERWILLIGER 21 Oct. 1986 607 p
(Contract NAG1-138)
(NASA-CR-180276; NAS 1.26:180276) Avail: NTIS HC A99/MF A01 CSCL 09B

Research into software development is required to reduce its production cost and to improve its quality. Modern software systems, such as the embedded software required for NASA's space station initiative, stretch current software engineering techniques. The requirements to build large, reliable, and maintainable software systems increases with time. Much theoretical and practical research is in progress to improve software engineering techniques. One such technique is to build a software system or environment which directly supports the software engineering process, i.e., the SAGA project, comprising the research necessary to design and build a software development which automates the software engineering process. Progress under SAGA is described. Author

N87-29002# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systemes Balistiques et Spatiaux.
COMPUTER SIMULATION OF DEPLOYMENT
CH. ROUX and P. FLAMENT *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 305-311 Nov. 1986
Avail: NTIS HC A21/MF A01

A solar array deployment analysis software, ADAMS, was developed. The ADAMS program improves predictability of dynamic phenomena during deployment; understanding of influences from component flexibilities during deployment; and inflight predictions (geometry, spacecraft motions). These enhance accuracy in optimizing mechanisms as to mechanical strength under deployment loads and latching shocks, motorization factors, and layout on solar array; and predicting all in-orbit deployment (including, possibly, failure) cases to make sure of no unexpected disturbances of spaceflight. Ground tests of deployment geometry can be eliminated. ESA

N87-29129*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ENGINEERING GRAPHICS AND IMAGE PROCESSING AT LANGLEY RESEARCH CENTER
SUSAN J. VOIGT *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 1 5 p Aug. 1985
Avail: NTIS HC A16/MF A01 CSCL 09B

The objective of making raster graphics and image processing techniques readily available for the analysis and display of engineering and scientific data is stated. The approach is to develop and acquire tools and skills which are applied to support research activities in such disciplines as aeronautics and structures. A listing of grants and key personnel are given. R.J.F.

N87-29893# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Mathematics.

MODELING AND COMPUTATIONAL ALGORITHMS FOR PARAMETER ESTIMATION AND OPTIMAL CONTROL OF AEROELASTIC SYSTEMS AND LARGE FLEXIBLE STRUCTURES Final Report, 30 Sep. 1985 - 30 Sep. 1986

J. A. BURNS and E. M. CLIFF 1 Nov. 1986 5 p
(Contract AF-AFOSR-0287-85)
(AD-A183302; AFOSR-87-0956TR) Avail: NTIS HC A02/MF A01 CSCL 20K

The goal of this research is to develop computational algorithms for identifications and control, especially with application to aeroelastic and viscoelastic systems. The research has emphasized development of Chandresekhar algorithms for optimal control of distributed systems and state models and computational algorithms for aeroelastic control systems. During this period, the investigators developed fast algorithms for the general linear quadratic optimal control problems for functional differential equations using Chandresekhar factorization techniques. The resulting algorithms show improved rates of convergence over Ricatti techniques and for certain large problems is the only algorithms which was shown to converge in practice. Nine publications were produced during this period under this grant, including Factorization and Reduction Methods for Optimal Control of Hereditary Systems and Modeling and Approximation for a Viscoelastic Control Problem. GRA

N87-30107*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A SPLINE-BASED PARAMETER AND STATE ESTIMATION TECHNIQUE FOR STATIC MODELS OF ELASTIC SURFACES

H. T. BANKS, P. L. DANIEL (Southern Methodist Univ., Dallas, Tex.), and E. S. ARMSTRONG 28 Jun. 1983 62 p
(Contract NAS1-15810; NAS1-16394; NAG1-258; NSF MCS-82-05355; AF-AFOSR-0198-81; NSF MCS-82-00883)
(NASA-CR-180449; ICASE-83-25; NAS 1.26:180449) Avail: NTIS HC A04/MF A01 CSCL 12A

Parameter and state estimation techniques for an elliptic system arising in a developmental model for the antenna surface in the Maypole Hoop/Column antenna are discussed. A computational algorithm based on spline approximations for the state and elastic parameters is given and numerical results obtained using this algorithm are summarized. Author

03

STRUCTURAL CONCEPTS

Includes analyses and descriptions of different Space Station structural concepts, arrangements, testing, methods of construction and/or manufacturing and specific rotary joints, structural nodes, and columns.

A87-31505

FIBER-OPTIC MONITORS FOR SPACE STRUCTURES

W. S. OTAGURO, R. J. MICHAL, and S. F. WATANABE (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 433-436. refs

The application of fiber-optic interferometric sensors for space use is becoming very attractive due to significant progress made in recent years in the development of producible fiber-optic modules. Both Mach-Zehnder or Sagnac configurations can be used to provide either length and area structural monitors. Fiber-optic length monitors can measure strains (elongations and compressions) from 0.1 micrometers to 1.0 millimeters from dc to 2000 Hz with a temperature compensation. Fiber-optic acoustic area monitors can locate and quantify structural damage caused by micrometeorite impacts or surface defects. By incorporating the fiber-optic sensor technology from related efforts, the development of these fiber-optic structural monitors is reduced to transducer design and packaging. A description of the Mach-Zehnder and Sagnac fiber interferometers configured to monitor strain is provided. Data from a breadboard Sagnac strain sensor is presented. Author

A87-32058* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A SPACE DEBRIS SIMULATION FACILITY FOR SPACECRAFT MATERIALS EVALUATION

ROY A. TAYLOR (NASA, Marshall Space Flight Center, Huntsville, AL) SAMPE Quarterly (ISSN 0036-0821), vol. 18, Jan. 1987, p. 28-34. refs

A facility to simulate the effects of space debris striking an orbiting spacecraft is described. This facility was purchased in 1965 to be used as a micrometeoroid simulation facility. Conversion to a Space Debris Simulation Facility began in July 1984 and it was placed in operation in February 1985. The facility consists of a light gas gun with a 12.7-mm launch tube capable of launching 2.5-12.7 mm projectiles with a mass of 4-300 mg and velocities of 2-8 km/sec, and three target tanks of 0.067 m, 0.53 a m and 28.5 a m. Projectile velocity measurements are accomplished via pulsed X-ray, laser diode detectors, and a Hall photographic station. This facility is being used to test development structural configurations and candidate materials for long duration orbital spacecraft. A summary of test results are also described. Author

A87-32120

SPACE STRUCTURE VIBRATION MODES - HOW MANY EXIST? WHICH ONES ARE IMPORTANT?

PETER C. HUGHES (Toronto, University, Downsview, Canada) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Feb. 1987, p. 22-28. refs
(Contract NSERC-A-4183)

Basic concepts of vibration modes analysis are re-evaluated to demonstrate techniques for discerning between significant physical vibration modes and mathematical models of modes. Generic integral equations are defined for the modal coefficients of momentum and angular momentum. When applied to a complex structure, the equations are solved by convergence of finite element calculations, i.e., an approximation is made. The calculations are a numerical equivalent of exact solutions to partial differential equations, but do not extend to 'absurd' orders of modes. Low frequency modes are identified as the important modes. Error indices are discussed for truncating the number of modes that must be considered, noting that frequency is not the only parameter of importance in modal selection. M.S.K.

A87-32229#

ROBUST CONTROLLER DESIGN USING FREQUENCY DOMAIN CONSTRAINTS

R. D. HEFNER (Aerospace Corp., El Segundo, CA) and D. L. MINGORI (California, University, Los Angeles) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 158-165. refs

This paper describes a method for designing a controller with improved robustness with respect to truncated flexible modes. The approach involves minimization of a quadratic performance index subject to constraints in the frequency domain. The frequency domain criteria are chosen so as to sufficiently attenuate the high frequency response of the full dynamic system while attempting to maintain the overall performance of the closed-loop system. The resulting constraint relationships are cast into a functional minimization framework and parameter optimization techniques are used to determine the solution. Author

A87-32336* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

VALIDATION OF LARGE SPACE STRUCTURES BY GROUND TESTS

B. K. WADA, C. P. KUO, and R. J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: International Symposium on Space Technology and Science, 15th,

Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 465-474. refs
(Contract NAS7-918)

The paper presents concepts designed to validate, through the use of ground tests, mathematical models of continuous type structures and structures comprised of interconnecting subsystems. For continuous-type structures, a multiple boundary condition test approach is considered in which the basic idea is to perform a large number of tests using artificial boundary conditions from which good ground test data can be obtained. The test ensures an arbitrarily large number of test data for use in the validation and updating of the mathematical model. Another approach, applicable to structures comprised of subsystems, involves the identification of significant structural elements for the system dynamic model which are not validated by standard modal tests of the subsystems. K.K.

A87-32337* Howard Univ., Washington, D. C.

A REVIEW OF MODELLING TECHNIQUES FOR THE OPEN AND CLOSED-LOOP DYNAMICS OF LARGE SPACE SYSTEMS

PETER M. BAINUM (Howard University, Washington, DC) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 475-482. Research supported by Howard University and Nippon Telegraph and Telephone Public Corp. refs
(Contract NSG-1414)

This paper reviews the steps in the development of mathematical models that can be used to simulate the in-orbit dynamic behavior of large flexible systems. A general continuum formulation is compared with the hybrid coordinate formulation and also a finite element representation of the total system. A review of structural analysis routines emphasizes the use of computer generated graphics to help understand the different modal elastic shape functions of complex systems. Numerical techniques employed to synthesize shape and attitude control laws are summarized. Finally, the modeling of environmental disturbance torques due to the interaction of solar radiation pressure on vibrating and thermally deflected systems is discussed. Author

A87-32340

DESIGN CONSIDERATION OF MECHANICAL AND DEPLOYMENT PROPERTIES OF A COILABLE LATTICE MAST

K. OKAZAKI, S. SATO, A. OBATA (Japan Aircraft Manufacturing Co., Ltd., Yokohama, Japan), M. NATORI, and K. MIURA (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 497-502.

An analytical approach is presented to extract suitable values of elements for fundamental design of coilable lattice masts. The large deflection of each element in the transition zone makes the analysis difficult. In this paper, deploying mode analyses using strain energy calculations with some reasonable assumptions based on experimental results are presented. Author

A87-32405

THERMAL DEFORMATION AND ELECTRICAL DEGRADATION OF ANTENNA REFLECTOR WITH TRUSS BACKSTRUCTURE

KOHEI OHATA and TAKEHIKO KOBAYASHI (Nippon Telegraph and Telephone Public Corp., Yokosuka Electrical Communications Laboratory, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 955-960.

A large high-precision reflector required for 20/30 GHz multibeam on-board antennas is investigated. A reflector with a truss back-structure constructed of CFRP is expected to have good performance in suppression of excessive thermal deformations in space. The thermal deformation characteristics of this antenna are estimated both experimentally and analytically. The effects of the deformation on electrical performance are analyzed, giving special attention to the multibeam applications. It is observed that the periodic deformation has a pronounced effect on sidelobe level. Author

A87-32442

FLEXIBILITY CONTROL OF TORSIONAL VIBRATIONS OF A LARGE SOLAR ARRAY

TOSHIO FUKUDA, HIDEMI HOSOGAI (Tokyo University of Science, Japan), NOBUYUKI YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Tsukuba, Japan), and FUMIHITO ARAI IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1243-1248. refs

This paper describes modeling and control methods for torsional vibration of flexible solar arrays. The eigenvalues and eigenfunctions for this distributed parameter system are solved both mathematically and numerically under the consideration of the inertia momentum of the supported rigid attachment. A differential solar cells sensor consisting of a pair of adjacent solar cells is proposed as a new type of sensor to measure the attitude and torsional vibrations of flexible solar arrays. To eliminate noises in the sensor outputs, the Kalman filtering method is employed. A proposed mode estimation method, based on this linear optimal filter, is show to give good results. The control method employing the optimal control theory, based on the quadratic performance index approach, is also shown to suppress the torsional vibration of the flexible array. Author

A87-32443

TWO-TIME-SCALE DESIGN OF ROBUST CONTROLLERS FOR LARGE STRUCTURE SYSTEMS

M. SUZUKI (Nagoya University, Japan), T. NARUSE (Daido Institute of Technology, Nagoya, Japan), Y. ANDO (Nagoya Municipal Industrial Research Institute, Japan), and S. KURACHI IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1249-1254.

The two time-scale design method of the singular perturbation system is decribed. The design method is used to determine the robust control design for large structure systems; the method is applied to the vibration control of a flexible beam. The advantages of the singular perturbation method for determining the robust stabilization control for large structure systems are discussed. I.F.

A87-32545

STUDY OF ACTUATOR FOR LARGE SPACE MANIPULATOR ARM

K. MACHIDA, T. IWATA, Y. TODA, M. KAWADA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Sakura, Japan), Y. KURITA (Toshiba Corp., Kawasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2017-2022.

Results are reported from studies of basic technologies for a long-life RMS for the Space Station, mostly for use with the Japan Module. The new arm will provide 10 m reach and will need high torque and a lifetime of more than 10 yr. The research covered an actuator model developing 700 Nm torque at 0.05 rad/sec and 3.4 Nm at 17.6 rad/sec with a reduction ratio of 351 in the planetary gear box, a ratio which permits use of a solid lubricant. A cutaway view is provided of the actuator, which has a dc brushless motor with 3-phase windings and a rare-earth metal magnet. The gear testing equipment employed in 1111 hr tests to validate the actuator performance in vacuum is also described. Gear alloys and greases which exhibited satisfactory durability in the tests are identified. M.S.K.

A87-32546

STRUCTURE AND FUNCTION OF DEPLOYABLE TRUSS BEAM (DTB)

SEISHIRO KIBE, YOSHINORI FUJIMORI (National Aerospace

Laboratory, Tokyo, Japan), KUNIHIKO KAWAKAMI, TATSUYA HAMAGUCHI, MASAYUKI TOMITA (Mitsubishi Electric Corp., Amagasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2035-2040.

This paper describes the concept study of the deployable truss beam (DTB) and the development of its key parts (i.e., two types of latches). DTB will be applicable to the common facility of the Space Station and as a supportive bench for specific missions, for it can provide the adequate field of view, cut off contamination from/to the Space Station core and enlarge the working area. The Solar Energy Concentration System, the Large Antenna assembly, and Tether Boomerang systems are supposed to be prospective missions for DTB. Author

A87-32658* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

STATIC SHAPE CONTROL FOR FLEXIBLE STRUCTURES

G. RODRIGUEZ and R. E. SCHEID, JR. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 16 p. NASA-supported research.
(SAE PAPER 861822)

An integrated methodology is described for defining static shape control laws for large flexible structures. The techniques include modeling, identifying and estimating the control laws of distributed systems characterized in terms of infinite dimensional state and parameter spaces. The models are expressed as interconnected elliptic partial differential equations governing a range of static loads, with the capability of analyzing electromagnetic fields around antenna systems. A second-order analysis is carried out for statistical errors, and model parameters are determined by maximizing an appropriate defined likelihood functional which adjusts the model to observational data. The parameter estimates are derived from the conditional mean of the observational data, resulting in a least squares superposition of shape functions obtained from the structural model. M.S.K.

A87-32729

THE MAST FLIGHT SYSTEM DYNAMIC CHARACTERISTICS AND ACTUATOR/SENSOR SELECTION AND LOCATION

J. W. SHIPLEY and D. C. HYLAND (Harris Corp., Melbourne, FL) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 31-49.
(AAS PAPER 86-003)

The NASA Mast Flight System (MFS), which will serve as a test bed for the development of validation methodology for large space structures (LSS) and the accompanying control design methodology, is described. MFS will consist of a deployable/retractable truss beam 60 m or greater in length with a 100 kg tip mass, the latter being included to couple the first torsional mode with either the first or second bending mode. The system will include the capability of parameter alterations to change the modal frequency spacing and couple modes geometrically in a controlled manner. The design criteria for the MFS to ensure that the tests are valid for larger structures, cost-effective to perform, and harmonious with Orbiter operations are delineated. The designs, placement and operations of the linear dc motor actuators to achieve the mission goals are summarized. M.S.K.

A87-33551

STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 28TH, MONTEREY, CA, APR. 6-8, 1987, TECHNICAL PAPERS. PART 1

Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1987, 884 p. For individual items see A87-33552 to A87-33653.

The present conference considers the structural behavior of solid rocket motor field joints, design engineering technologies for aerospace vehicles, the generalization of an equivalent plate representation for aircraft structural analysis, control-augmented structural synthesis with transient response constraints, the optimal design of flexible arches, compressive deformation in polymer fibers, a probabilistic Hu-Washizu variational principle, the extension-twist coupling of composite circular tubes for tilt rotor blade applications, and a creep-rupture model of filament-wound spherical pressure vessels. Also discussed are tough advanced composite structures, simultaneous structure/control optimization of large flexible spacecraft, improved optimum design of dewar supports, the shear strength of structural adhesives, the performance of trigonometric-basis function finite elements in Timoshenko beams, on-orbit damage assessment for large space structures, and the structural tailoring of advanced turboprops. O.C.

A87-33564#

AN EQUIVALENT CONTINUUM ANALYSIS PROCEDURE FOR SPACE STATION LATTICE STRUCTURES

JOHN O. DOW and STEPHEN A. HUYER (Colorado, University, Boulder) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 110-122. refs
(AIAA PAPER 87-0724)

A procedure for determining the equivalent continuum properties of a structure composed of repeated patterns of discrete elements with both displacement and rotation coordinates is presented. These nodal coordinates are transformed to rigid body and strain gradient variables using a polynomial representation. The set of independent strain gradient variables is identified by inspection and depends on the geometry of the structure being modeled. The possibility of introducing errors by requiring the analyst to supply the strain gradient terms directly is eliminated. The procedure is applied to six example problems, including two in which the effect of structural damage on the stiffness characteristics of the structure is analyzed. The compactness of the procedure makes it particularly suited for the preliminary design stage and implementation on personal computers. Author

A87-33565*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A LANCZOS EIGENVALUE METHOD ON A PARALLEL COMPUTER

SUSAN W. BOSTIC and ROBERT E. FULTON (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Actronautics, 1987, p. 123-134. refs
(AIAA PAPER 87-0725)

Eigenvalue analyses of complex structures is a computationally intensive task which can benefit significantly from new and impending parallel computers. This study reports on a parallel computer implementation of the Lanczos method for free vibration analysis. The approach used here subdivides the major Lanczos calculation tasks into subtasks and introduces parallelism down to the subtask levels such as matrix decomposition and forward/backward substitution. The method was implemented on a commercial parallel computer and results were obtained for a long flexible space structure. While parallel computing efficiency is problem and computer dependent, the efficiency for the Lanczos method was good for a moderate number of processors for the test problem. The greatest reduction in time was realized for the decomposition of the stiffness matrix, a calculation which took 70 percent of the time in the sequential program and which took 25 percent of the time on eight processors. For a sample calculation of the twenty lowest frequencies of a 486 degree of freedom problem, the total sequential computing time was reduced by almost a factor of ten using 16 processors. Author

A87-33569#

STRUCTURAL OPTIMIZATION WITH FREQUENCY CONSTRAINTS

R. V. GRANDHI (Wright State University, Dayton, OH) and V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson

AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 322-333. USAF-supported research. refs
(AIAA PAPER 87-0787)

This paper presents a design optimization algorithm for structural weight minimization with multiple frequency constraints. An optimality criterion method based on uniform Lagrangian density for resizing and a scaling procedure to locate the constraint boundary were used in optimization. Multiple frequency constraints of equality and inequality types were addressed. The effectiveness of the algorithm was demonstrated by designing a number of truss structures with as many as four hundred and eighty nine design variables. The algorithm is extremely stable and in all cases the optimum designs were obtained in less than twenty iterations regardless of the size of the structure and the number of design variables. Author

A87-33591#
ROBUSTNESS OPTIMIZATION OF STRUCTURAL AND CONTROLLER PARAMETERS
KYONG B. LIM (Virginia Polytechnic Institute and State University, Blacksburg) and JOHN L. JUNKINS (Texas A & M University, College Station) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 351-361. refs
(Contract F49620-86-K-0014)
(AIAA PAPER 87-0791)

A unified approach to structure and controller design optimization is presented showing several novel ideas in the definition and optimization of robustness for structures and structural controllers. A robustness bound due to Patel and Toda is developed using conditioning analysis of the closed loop eigenvalue problem. Homotopy and sequential linear programming algorithms are used, in lieu of conventional nonlinear programming, to implement these ideas for an illustrative example. The numerical results confirm the conservatism of the stability robustness bound for highly structured perturbations but nevertheless clearly support the hypothesis that maximizing the robustness measure does significantly increase the true robuctness of a closed loop system. Author

A87-33610*# Tokyo Univ. (Japan).
SIMULTANEOUS STRUCTURE/CONTROL OPTIMIZATION OF LARGE FLEXIBLE SPACECRAFT
JUNJIRO ONODA (Tokyo, University, Japan) and RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 501-507. refs
(Contract NAG1-224)
(AIAA PAPER 87-0823)

This paper presents an approach to the simultaneous optimal design of a structure and control system for large flexible spacecrafts based on realistic objective function and constraints. The weight or total cost of structure and control system is minimized subject to constraints on the magnitude of response to a given disturbance involving both rigid-body and elastic modes. A nested optimization technique is developed to solve the combined problem. As an example, simple beam-like spacecraft under a steady-state white-noise disturbance force is investigated and some results of optimization are presented. In the numerical examples, the stiffness distribution, the location of controller and the control gains are optimized. Direct feedback control and linear quadratic optimal control laws are used with both inertial and non-inertial disturbing force. It is shown that the total cost is sensitive to the overall structural stiffness so that a simultaneous optimization of the structure and control system is indeed useful. Author

A87-33611*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATED STRUCTURAL ELECTROMAGNETIC OPTIMIZATION OF LARGE SPACE ANTENNA REFLECTORS
S. L. PADULA, H. M. ADELMAN, and M. C. BAILEY (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 508-517. refs
(AIAA PAPER 87-0824)

The requirements for extremely precise and powerful large space antenna reflectors have motivated the development of a procedure for shape control of the reflector surface. A mathematical optimization procedure has been developed which improves antenna performance while minimizing necessary shape correction effort. In contrast to previous work which proposed controlling the rms distortion error of the surface thereby indirectly improving antenna performance, the current work includes electromagnetic (EM) performance calculations as an integral part of the control procedure. The application of the procedure to a radiometer design with a tetrahedral truss backup structure demonstrates the potential for significant improvement. The results indicate the benefit of including EM performance calculations in procedures for shape control of large space antenna reflectors. Author

A87-33613*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTIMIZATION PROCEDURE TO CONTROL THE COUPLING OF VIBRATION MODES IN FLEXIBLE SPACE STRUCTURES
JOANNE L. WALSH (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 525-534. refs
(AIAA PAPER 87-0826)

As spacecraft structural concepts increase in size and flexibility, the vibration frequencies become more closely-spaced. The identification and control of such closely-spaced frequencies present a significant challenge. To validate system identification and control methods prior to actual flight, simpler space structures will be flown. To challenge the above technologies it will be necessary to design these structures with closely-spaced or coupled vibration modes. Thus there exists a need to develop a systematic method to design a structure which has closely-spaced vibration frequencies. This paper describes an optimization procedure which is used to design a large flexible structure to have closely-spaced vibration frequencies. The procedure uses a general-purpose finite-element analysis program for the vibration and sensitivity analyses and a general-purpose optimization program. Results are presented from two studies. The first study uses a detailed model of a large flexible structure to design a structure with one pair of closely-spaced frequencies. The second study uses a simple equivalent beam model of a large flexible structure to obtain a design with two pairs of closely-spaced frequencies. Author

A87-33632#
NEW CONCEPTS OF DEPLOYABLE TRUSS UNITS FOR LARGE SPACE STRUCTURES
KIYOSHI TAKAMATSU (Fuji Heavy Industries, Ltd., Tochigi, Japan), JUNJIRO ONODA (Tokyo, University, Japan), and KEN HIGUCHI (Tokyo University of Electrical Engineering, Saitama, Japan) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 695-704. refs
(AIAA PAPER 87-0868)

Concepts of two types of newly proposed deployable hexahedral truss units are presented. One of them, which is called Sliding Hinge Double Fold (SHDF), is the concept which is suitable for the application to the macroscopic two- or three-dimensional structures, while the other, which is called Sliding Hinge Single Fold (SHSF), for the application to the macroscopic one dimensional structures. Comparative study with existing deployable concepts indicates that both concepts can achieve almost the same or in some cases better packaging efficiency with fewer mechanisms for the truss to be folded. Function models were fabricated and tested to demonstrate the kinematic consistency of the concepts. Feasibility study of the application of SHDF to a large antenna structure is also performed. The finite element calculations were carried out to investigate effects of some design parameters on dynamic characteristics of two-dimensional platforms consisting of SHDF. Author

A87-33633*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
QUASI-STATIC SHAPE ADJUSTMENT OF A 15 METER DIAMETER SPACE ANTENNA
W. KEITH BELVIN, CATHERINE L. HERSTROM (NASA, Langley Research Center, Hampton, VA), and HAROLD H. EDIGHOFFER (Edighoffer, Inc., Newport News, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 705-713. refs
(AIAA PAPER 87-0869)

A 15 meter diameter Hoop-Column antenna has been analyzed and tested to study shape adjustment of the reflector surface. The Hoop-Column antenna concept employs pretensioned cables and mesh to produce a paraboloidal reflector surface. Fabrication errors and thermal distortions may significantly reduce surface accuracy and consequently degrade electromagnetic performance. Thus, the ability to adjust the surface shape is desirable. The shape adjustment algorithm consisted of finite element and least squares error analyses to minimize the surface distortions. Experimental results verified the analysis. Application of the procedure resulted in a reduction of surface error by 38 percent. Quasi-static shape adjustment has the potential for on-orbit compensation for a variety of surface shape distortions. Author

A87-33634*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON ORBIT DAMAGE ASSESSMENT FOR LARGE SPACE STRUCTURES
JAY-CHUNG CHEN and JOHN A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 714-721. refs
(Contract NAS7-918)
(AIAA PAPER 87-0870)

The need for monitoring the dynamic characteristics of large structural systems, for the purpose of assessing the potential degradation of structural properties, has been established. This paper develops a theory for assessing the occurrence, location, and extent of potential damage utilizing on-orbit response measurements. The feasibility of the method is demonstrated using a simple structural system as an example. Author

A87-33635#
DESIGN CONSIDERATIONS FOR A ONE-KILOMETER ANTENNA STICK
JANET E. FREEMAN (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) and CHARLES D. BABCOCK (California Institute of Technology, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 722-727.
(AIAA PAPER 87-0871)

Truss design equations for a large space structure are developed, using beam theory, from position knowledge accuracy requirements imposed on the structure. The maximum allowable spacing between position sensing points on the structure can be found by iteration. The underlying static structural analysis assumes a uniform transverse acceleration acting on the structure. Calculations for the design of a three-longeron truss are demonstrated for a satellite antenna stick with a required position knowledge accuracy of 0.5 cm. Author

A87-33636*# California Inst. of Tech., Pasadena.
IDENTIFICATION OF THE ZERO-G SHAPE OF A SPACE BEAM
GARY J. BALAS and CHARLES D. BABCOCK (California Institute of Technology, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 728-736. Research supported by the California Institute of Technology and NASA.
(AIAA PAPER 87-0872)

This paper develops an approach for identifying the 0-g shape of a beam/column in a 1-g environment. The determination of the 0-g shape is accomplished by a combination of experiment and analysis. A prototype large space structure beam/column is scaled to laboratory size to demonstrate that the 0-g shape of the structure can be accurately determined in a ground based experiment. Information obtained from the 0-g shape experiment is also used to experimentally measure the stiffness of the beam model.
Author

A87-33654
STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 28TH, MONTEREY, CA, APR. 6-8, 1987 AND AIAA DYNAMICS SPECIALISTS CONFERENCE, MONTEREY, CA, APR. 9, 10, 1987, TECHNICAL PAPERS. PARTS 2A & 2B
Conferences sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1987. Pt. 2A, 585 p.; pt. 2B, 572 p. For individual items see A87-33655 to A87-33761.

Papers are presented on an aeroelastic analysis of launch vehicles in transonic flight, the dynamical response to pulse excitations in large space structures, an analytical flutter investigation of a composite propfan model, and an analysis of Intelsat V flight data. Also considered are the effective stiffness of a structural component under parametric dynamic loading, the effect of nonlinearities on the dynamic response of a large Shuttle payload, and active suppression of an apparent shock induced instability. Other topics include positive position feedback control for large space structures, a flutter analysis of aeronautical composite structures by an improved supersonic kernel function method, and aeroelastic characteristics of swept circulation control wings. Papers are also presented on dynamic and attitude control characteristics of an International Space Station, wave propagation in periodic truss structures, and the hingeless rotor response to random gusts in forward flight. R.R.

A87-33656*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICAL RESPONSE TO PULSE EXCITATIONS IN LARGE SPACE STRUCTURES
MICHAIL ZAK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 31-39. refs
(Contract NAS7-918)
(AIAA PAPER 87-0710)

Finite dimensional approximations of large space structures as distributed parameter systems may lead to a loss of contribution of high frequencies to the dynamic response in case of impulsive or concentrated loads. It is shown that the unmodeled part of this response can be represented by a system of thin pulses which propagate as characteristic waves. It is demonstrated that the dynamical response to such a system of pulses can be modeled by a system of equations with delay argument. Fundamental dynamical properties of this system such as Liapunov stability, structural stability, loss of periodicity and transition to ergodicity are analyzed in this study. The results are illustrated by examples. Author

A87-33669#

AN IDENTIFICATION METHOD FOR FLEXIBLE STRUCTURES

NELSON G. CREAMER and JOHN L. JUNKINS (Texas A & M University, College Station) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 163-171. refs

(AIAA PAPER 87-0745)

A structural model identification method is developed for determination of the mass and stiffness matrices of an undamped structure along with the damping matrix of a lightly-damped structure. Utilizing measurements of natural frequencies, damping factors, and frequency response elements, a unique identification of the model is established through incorporation of the spectral decomposition of the frequency response function and the modal orthonormality conditions. Numerical simulations demonstrate the flexibility and potential of the proposed method. Author

A87-33670*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SYSTEM IDENTIFICATION OF A TRUSS TYPE SPACE STRUCTURE USING THE MULTIPLE BOUNDARY CONDITION TEST (MBCT) METHOD

C. P. KUO and B. K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 172-176. refs

(AIAA PAPER 87-0746)

Experimental results on the application of the multiple boundary condition test (MBCT) method to experimental hardware have validated its usefulness in the ground testing of large flexible space structures. Excellent results were obtained with a beam with a uniform cross-section and with a beam consisting of two different cross-sections alternately located. The MBCT method is then applied to a 12 bay MAST type structure which is part of the NASA COFS program, and the cross-sectional area of the updated mathematical model was found to be within 4.5 percent of the true value. R.R.

A87-33679#

ANALYSIS OF INTELSAT V FLIGHT DATA

T. RUSH, P. R. SCHRANTZ (COMSAT Laboratories, Clarksburg, MD), and B. AGRAWAL (INTELSAT, Washington, DC) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 253-257. COMSAT-INTELSAT-sponsored research.

(AIAA PAPER 87-0784)

This paper summarizes results of an extensive evaluation of the Intelsat V spacecraft flight data carried out by COMSAT Laboratories for INTELSAT. A structural loads data base for the Intelsat V was assembled including actual flight measurements, coupled loads analysis predictions, and environmental test loads. The flight measurements incorporate both accelerometer and strain gauge signals transmitted during eight Atlas/Centaur and two Ariane launches of the Intelsat V satellites. An evaluation of the loads data base placed primary emphasis on a comparison of coupled loads analysis predictions with statistically based flight loads. The predictions of axial acceleration at the spacecraft/launch vehicle interface were found to be accurate. However, the lateral loads predicted by the coupled loads analysis were overly conservative. Several discrepancies between the structural analysis and the flight measurements have been revealed. The influence of the spacecraft's dynamic characteristics on interface motions can be readily observed in the data. Author

A87-33689*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIENCE IN DISTRIBUTED PARAMETER MODELING OF THE SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) STRUCTURE

L. W. TAYLOR and D. S. NAIDU (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 330-343. refs

(AIAA PAPER 87-0895)

The Spacecraft Control Laboratory Experiment (SCOLE) configuration is used to compare exact and approximate solutions of the partial differential equations which define its structural dynamics. The need for a proof model for evaluating competing control laws demands that solutions be generated which not only exhibit accurate modal characteristics, but precise static deflections as well. Because precise pointing is required, the motion of the end bodies of the Shuttle-attached antenna must be known with great accuracy. Modal models are attractive because of their stable solutions but require hundreds of modes to obtain a static deflection accuracy of only one percent. Although proportional damping in bending agrees well with experimental results using the SCOLE experimental apparatus, modes which involve both torsion and bending differ significantly from proportional damping. A lumped mass model is used to generate exact static deflections, but only approximate modal characteristics. Asymptotic solutions to the distributed parameter system approximate very accurately the modal characteristics at high mode numbers. Ways are examined for refining the approximate solutions by applying a first-order variation and by employing singular perturbation techniques which are usually limited to ordinary differential equations. The most accurate solutions of the distributed parameter model of SCOLE are obtained by combining exact and asymptotic solutions. Author

A87-33706*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ON THE CONTROL OF FLEXIBLE STRUCTURES BY APPLIED THERMAL GRADIENTS

D. L. EDBERG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 544-550. refs

(AIAA PAPER 87-0887)

Thermal, elastic, and feedback analyses are applied to the case of a beam with a distributed thermal actuator. The actuator is capable of producing a thermal gradient across the section of the beam. One candidate for such an actuator uses the Peltier effect, which appears in certain semiconductors. These devices act as heat pumps when a voltage is applied, causing a temperature gradient. It is shown that the thermal gradients can induce deflection in the beam. If the thermal gradients are applied in the proper sense to a vibrating beam, it is possible to increase the vibration damping exhibited by the structure. Experimental results are given for a cantilever beam, whose first vibrational mode damping ratio was increased from 0.81 to 7.4 percent with a simple lead compensation. Author

A87-33708*# Texas A&M Univ., College Station.

DYNAMIC RESPONSE OF A VISCOELASTIC TIMOSHENKO BEAM

S. KALYANASUNDARAM, D. H. ALLEN, and R. A. SCHAPERY (Texas A & M University, College Station) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 559-567. refs

(Contract NAG[illegible])

(AIAA PAPER 87-0890)

The analysis presented in this study deals with the vibratory response of viscoelastic Timoshenko (1955) beams under the assumption of small material loss tangents. The appropriate method of analysis employed here may be applied to more complex structures. This study compares the damping ratios obtained from the Timoshenko and Euler-Bernoulli theories for a given viscoelastic material system. From this study the effect of shear deformation and rotary inertia on damping ratios can be identified. Author

A87-33709*# Boeing Aerospace Co., Seattle, Wash.
NONLINEAR TRANSIENT ANALYSIS OF JOINT DOMINATED STRUCTURES
J. M. CHAPMAN, F. H. SHAW, and W. C. RUSSELL (Boeing Aerospace Co., Seattle, WA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 568-577.
(Contract NAS8-36420)
(AIAA PAPER 87-0892)

A residual force technique is presented that can perform the transient analyses of large, flexible, and joint dominated structures. The technique permits substantial size reduction in the number of degrees of freedom describing the nonlinear structural models and can account for such nonlinear joint phenomena as free-play and hysteresis. In general, joints can have arbitrary force-state map representations but these are used in the form of residual force maps. One essential feature of the technique is to replace the arbitrary force-state maps describing the nonlinear joints with residual force maps describing the truss links. The main advantage of this replacement is that the incrementally small relative displacements and velocities across a joint are not monitored directly thereby avoiding numerical difficulties. Instead, very small and 'soft' residual forces are defined giving a numerically attractive form for the equations of motion and thereby permitting numerically stable integration algorithms. The technique was successfully applied to the transient analyses of a large 58 bay, 60 meter truss having nonlinear joints. A method to perform link testing is also presented. Author

A87-33711*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POSITIVE POSITION FEEDBACK CONTROL FOR LARGE SPACE STRUCTURES
J. L. FANSON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and T. K. CAUGHEY (California Institute of Technology, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 588-598. refs
(AIAA PAPER 87-0902)

A new technique for vibration suppression in large space structures is investigated in laboratory experiments on a thin cantilever beam. This technique, called Positive Position Feedback, makes use of generalized displacement measurements to accomplish vibration suppression. Several features of Positive Position Feedback make it attractive for the large space structure control environment: The realization of the controller is simple and straightforward. Global stability conditions can be derived which are independent of the dynamical characteristics of the structure being controlled, i.e., all spillover is stabilizing. The method cannot be destabilized by finite actuator dynamics, and the technique is amenable to a strain-based sensing approach. The experiments control the first six bending modes of a cantilever beam, and make use of piezoelectric materials for actuators and sensors, simulating a piezoelectric active-member. The modal damping ratios are increased by factors ranging from 2 to 130. Author

A87-33712*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SPILLOVER STABILIZATION AND DECENTRALIZED MODAL CONTROL OF LARGE SPACE STRUCTURES
EVA A. CZAJKOWSKI and ANDRE PREUMONT (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 599-609. refs
(Contract NAG1-603)
(AIAA PAPER 87-0903)

The stabilization of the neglected dynamics of the higher modes of vibration in large space structures is studied, and the influence of the structure of the plant noise intensity matrix of the Kalman-Bucy filter on the stability margin of the residual modes is shown. An optimization procedure uses information on the residual modes to minimize spillover of known residual modes while preserving robustness with respect to the unknown dynamics, and the optimum plant noise intensity matrix is selected to maximize the stability margins of the residual modes and to properly place the observer poles. Examples for both centralized and decentralized control are considered. R.R.

A87-33727#
MODAL ANALYSES OF DYNAMICS OF A DEFORMABLE MULTIBODY SPACECRAFT - THE SPACE STATION: A CONTINUUM APPROACH
HARI B. HABLANI (Rockwell International Corp., Satellite Systems Div., Seal Beach, CA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 753-768. refs
(AIAA PAPER 87-0925)

Two classes of modes for multibody deformable spacecraft which are completely free in space are formulated: (1) internal rigid body degrees of freedom (IRB) unconstrained modes, referring to free hinges; and (2) IRB-constrained modes, referring to locked hinges. A continuum formulation of the dynamics of the Space Station with a mobile manipulator is presented, and discretized equations of motion of the Space Station are obtained using both modes. Modal moment coefficients of both modes represent the linear and angular momentum of the vehicle and the angular momentum of the hinged bodies. The analysis is general, with elastic deformation being three-dimensional, and structures being of arbitrary geometry and obeying Hooke's law of elasticity. R.R.

A87-33737#
STRUCTURAL AND CONTROL OPTIMIZATION OF SPACE STRUCTURES
N. S. KHOT, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson, AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 850-860. USAF-supported research. refs
(AIAA PAPER 87-0939)

Results are obtained by three optimization algorithms to design the structure and control system with weight as the objective function and constraints on the closed-loop eigenvalue distribution and the damping parameters. The nonunique nature of the optimizations is discussed, and the minimization of the Frobenious norm is investigated. A two bar truss and an ACOSS-four structure were designed, and from numerical comparisons it is found that when the structure is completely constrained, minimization of the weight and the Frobenious norm both give identical results. Qualitative aspects of the optimum solutions are considered with the transient response and control effort simulations. R.R.

A87-33739*# PRC Kentron, Inc., Hampton, Va.
EFFECTS OF LOCAL VIBRATIONS ON THE DYNAMICS OF SPACE TRUSS STRUCTURES
DIRK B. WARNAAR (PRC Kentron, Inc., Hampton, VA) and PAUL

E. MCGOWAN (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 868-875.
(AIAA PAPER 87-0941)

The paper discusses the influence of local member vibrations on the dynamics of repetitive space truss structures. Several focus problems wherein local member vibration modes are in the frequency range of the global truss modes are discussed. Special attention is given to defining methods that can be used to identify the global modes of a truss structure amidst many local modes. Significant interactions between the motions of local member vibrations and the global behavior are shown to occur in truss structures when: (1) the natural frequencies of the individual members for clamped-clamped boundary conditions are in the vicinity of the global truss frequency; and (2) the total mass of the individual members represents a large portion of the mass of the whole structure. The analysis is carried out with a structural analysis code which uses exact member theory. The modeling detail required using conventional finite element codes to adequately represent such a class of problems is examined. The paper concludes with some practical considerations for the design and dynamic testing of structures which might exhibit such behavior. Author

A87-33741#

AN EXPERIMENTAL STUDY OF TRANSIENT WAVES IN A PLANE GRID STRUCTURE

WILLIAM L. HALLAUER, JR. and DINESH J. TRIVEDI (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 888-899. refs
(Contract F49620-85-C-0024)
(AIAA PAPER 87-0943)

Flexural waves were generated and measured in a two-dimensional laboratory structure which is dynamically representative in many respects of flexible large spacecraft structures. The structure's first vibration mode is at 0.6 Hz, and its average modal density for 0-100 Hz is 0.55 mode/Hz. The excitation used was suddenly applied sinusoidal forcing at a point on the structure, with frequencies of 30, 60, 120 and 240 Hz. Time series motion responses were measured at several points on the structure, permitting observation of the wavefront traveling outward from the point of excitation. Complementary theoretical transient responses were computed for a refined finite element model of the laboratory structure, and the theoretical predictions are compared with the experimental measurements. Author

A87-33742#

WAVE PROPAGATION IN PERIODIC TRUSS STRUCTURES

A. H. VON FLOTOW (MIT, Cambridge, MA) and JOEL SIGNORELLI IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 900-909. refs
(AIAA PAPER 87-0944)

Wave propagation in periodic truss-work structures is analytically investigated. Transfer matrix methods are applied to the analysis of a truss beam. The results, with members modeled as rods with pinned joints, agree well with results obtained from an equivalent continuum model of the same structure. Use of beam models for the members, including bending, shows that the pinned rod model loses fidelity above the first resonant frequency of lateral motion of the members. The truss, modeled with beam members exhibits complicated mechcnical filtering properties. Fixed and free boundary conditions are converted to reflection matrices. The phase closure principle is invoked to predict natural frequencies of a fixed-free portion of the truss. It is found that closely spaced resonant frequencies are *not* identified by this method. Computed results show subtle erroneous characteristics which are attributed to numerical effects. Author

A87-33745#

LOCALIZATION OF VIBRATIONS IN LARGE SPACE REFLECTORS

ODDVAR O. BENDIKSEN (Princeton University, NJ) and PHILLIP J. CORNWELL IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 925-935. refs
(AIAA PAPER 87-0949)

A study is presented of the mode localization phenomenon in a generic class of large space reflectors. The study is based on a Rayleigh-Ritz formulation using the first five cantilevered beam bending modes and a finite element formulation using Bernoulli-Euler beam elements. Coupling between the structures is provided by massless axial members. Numerical results indicate that mode localization does in fact occur in engineering structures of this type. Localization is characterized by the amplitude of a global mode becoming confined to a local region of the structure. For the 18-rib reflector studied, the first rib bending mode did not localize but the second and third modes did. Localization is found to become more severe with increasing mode number. Increasing the number of ribs to 48 resulted in significant distortion in some of the first rib bending modes and severe localization of the second and third bending modes. The phenomenon of wave confinement in finite structures is also demonstrated using a single-degree-of-freedom per substructure model. Author

A87-33751#

OPTIMAL VIBRATION CONTROL BY THE USE OF PIEZOCERAMIC SENSORS AND ACTUATORS

S. HANAGUD, A. J. CALISE (Georgia Institute of Technology, Atlanta), and M. W. OBAL IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 987-997. refs
(AIAA PAPER 87-0959)

In this paper, a discrete degrees of freedom model has been formulated for a structural dynamic system consisting of a linear elastic structure, bonded piezoceramic sensors and actuators and a feedback signal conditioning system. The formulated analytical model has been used to develop a procedure for optimum control by minimizing a quadratic performance index of state and control vectors using limited state feedback. An example of a linear elastic beam with piezoceramic sensors and actuators occupying discrete subdomains of the beam upper and lower surfaces has been used to illustrate the developed optimal control procedure. A model for the linear elastic beam has been obtained by using test results and a structural dynamic system identification method based on an equation error approach. Author

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ON SINE DWELL OR BROADBAND METHODS FOR MODAL TESTING

JAY-CHUNG CHEN and BEN K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 998-1004. refs
(Contract NAS7-918)
(AIAA PAPER 87-0961)

For large, complex spacecraft structural systems, the objectives of the modal test are outlined. Based on these objectives, the comparison criteria for the modal test methods, namely, the broadband excitation and the sine dwell methods are established. Using the Galileo spacecraft modal test and the Centaur G Prime upper stage vehicle modal test as examples, the relative advantages or disadvantages of each method are examined. The usefulness or shortcoming of the methods are given from a practicing engineer's view point. Author

A87-33754#
A MODERN APPROACH FOR MODAL TESTING USING MULTIPLE INPUT SINE EXCITATION
DAVID L. HUNT (SDRC, Inc., San Diego, CA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1016-1023. refs
(AIAA PAPER 87-0964)

Sinusoidal excitation continues to be the method preferred by many companies for conducting modal tests of structures. Frequency-response-based modal analysis has been made popular and shown to be quite accurate through the use of multiple input random excitation. A multiple input sine excitation capability has been developed and implemented which retains the benefits associated with both normal mode testing and frequency response function measurement and analysis. A digitally based system has replaced analog/manual force appropriation and control with a multichannel system that automates both exciter control and data acquisition. Other important aspects of the system include determination of force appropriation, informative graphic displays, and system portability. Author

A87-33756*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTIMAL PLACEMENT OF EXCITATIONS AND SENSORS FOR VERIFICATION OF LARGE DYNAMICAL SYSTEMS
M. SALAMA, T. ROSE, and J. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1024-1031. refs
(AIAA PAPER 87-0782)

The computationally difficult problem of the optimal placement of excitations and sensors to maximize the observed measurements is studied within the framework of combinatorial optimization, and is solved numerically using a variation of the simulated annealing heuristic algorithm. Results of numerical experiments including a square plate and a 960 degrees-of-freedom Control of Flexible Structure (COFS) truss structure, are presented. Though the algorithm produces suboptimal solutions, its generality and simplicity allow the treatment of complex dynamical systems which would otherwise be difficult to handle. R.R.

A87-33757#
LOCALIZATION IN DISORDERED PERIODIC STRUCTURES
GLEN J. KISSEL IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1046-1055. USAF-supported research. refs
(AIAA PAPER 87-0819)

Disorder in periodic structures is known to cause spatial localization of normal modes and attenuation of waves in all frequency bands. This paper uses a wave perspective to investigate these effects on one-dimensional periodic structures of interest to the engineer. Relevant work in the fields of solid state physics and mathematics is reviewed. A limit theorem for products of random matrices is exploited to calculate localization effects as a function of frequency. Localization is studied on two disordered periodic systems using both theoretical calculations and Monte Carlo simulations. The problem of localization in multiwave systems is briefly discussed. Author

A87-34467#
ALTERNATIVE METHODS TO FOLD/DEPLOY TETRAHEDRAL OR PENTAHEDRAL TRUSS PLATFORMS
JUNJIRO ONODA (Tokyo, University, Japan) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Mar.-Apr. 1987, p. 183-186. refs

Deployable tetrahedral and pentahedral truss platforms call for designs minimizing the number of central joints that must be provided with weight-increasing lock mechanisms; this requires the reduction of the number of struts to be folded, extended or contracted. The methods presented accomplish this goal with a 50-percent reduction in total strut number, by making the number of members to be folded or elongated average six per unit module. In addition, the number of face members to be folded or elongated is decreased to one-third that of a conventional truss platform. O.C.

A87-34310#
COMPARISON OF THE CRAIG-BAMPTON AND RESIDUAL FLEXIBILITY METHODS OF SUBSTRUCTURE REPRESENTATION
DANIEL C. KAMMER and MARY BAKER (Structural Dynamics Research Corp., San Diego, CA) (Structures, Structural Dynamics and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 2, p. 699-706) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 262-267. Previously cited in issue 13, p. 1900, Accession no. A85-30399. refs

A87-34701#
ON A BALANCED PASSIVE DAMPING AND ACTIVE VIBRATION SUPPRESSION OF LARGE SPACE STRUCTURES
S. S. SIMONIAN, M. S. LUKICH, and R. GLUCK (TRW, Inc., Engineering and Test Div., Redondo Beach, CA) AIAA, Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987. 33 p. refs
(AIAA PAPER 87-0901)

A methodology which blends passive damping and active vibration suppression of large space structures is described. The methodology involves the development of a finite element model of the spacecraft, analysis of the system requirements for the mission, identification of the spacecraft natural modes that require damping augmentation, and the incorporation of damping in the model. Weight cost functions for active and passive suppression systems are developed and compared. The methodology is evaluated by employing it in a laboratory demonstration of a space structure reflecting and/or transmitting electromagnetic radiation. The horizontal displacement and rotation of the simulated mirror are measured by a surface accuracy measurement system. The data from a single vertical column and a complete structure test are analyzed. The control problem is examined and the performance of the open- and closed-loop response characteristics are assessed. It is determined that the modal strain energy methodology is useful for the blending of active and passive damping systems. I.F.

A87-35327
REDUCED MODELING AND ANALYSIS OF LARGE REPETITIVE SPACE STRUCTURES VIA CONTINUUM/DISCRETE CONCEPTS
KUMAR K. TAMMA and KONG C. SAW (West Virginia University, Morgantown) Computers and Structures (ISSN 0045-7949), vol. 25, no. 3, 1987, p. 321-333. refs

The paper describes reduced modeling/analysis approaches for repetitive lattice configurations with emphasis on tetrahedral-type space structures although the basic concepts can be extended to general repetitive lattice structures as well. The approach is based on transforming the actual configuration to a significantly reduced discrete configuration using scaling transformations and constitutive properties derived via the concept of equivalent continuum. The approach seeks to model/analyze the much simpler and reduced configurations, and transformations and extrapolation/interpolation procedures are utilized to relate back the response to that of the significantly complex actual configurations. The effectiveness and accuracy of the approach is demonstrated via comparisons with detailed analysis of the actual models. Response due to geometric non-linear effects are also evaluated. The overall results obtained are in good agreement with the approach offers potential for further extension. Author

A87-38279

COMPARISON OF SATELLITE SUPPORT STRUCTURE ALUMINUM VERSUS GRAPHITE EPOXY

JOSEPH G. LOTTA (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 18 p. (SAWE PAPER 1692)

A program is described aimed at achieving minimum-weight hardware for the GOES (Geostationary Operational Environmental Satellite) spacecraft while meeting requirements for load-carrying capability and adequate stiffness, with additional constraints of meeting or surpassing all existing structural and thermal requirements and introducing no redesign of remaining spacecraft elements. The program involved engineering tradeoff and manufacturing development to replace aluminum support structure with graphite/epoxy resin laminates. Manufacturing techniques were developed in-house to lay up a hybrid composite laminate of high-modulus GY-70 and high-strength Celion 3000 and to debulk the layups to eliminate air pockets in a light vacuum bag at room temperature, usually overnight. Proof load tests demonstrated that strength and stiffness requirements were met or improved upon, and a 60 percent weight saving was achieved at a cost of $27,500 per pound saved (slightly more than half the maximum cost allowed per pound saved). D.H.

A87-38880

JOINT TECHNOLOGY FOR GRAPHITE EPOXY SPACE STRUCTURES

D. M. MAZENKO, G. A. JENSEN, and P. J. MCCORMICK (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 401-413.

Graphite epoxy tubes are commonly used to construct truss assemblies for spacecraft application. The joining of these tubes usually employs metallic end fittings attached to the ends of the tubes. This paper describes tube development, and methods for bonding tubes to aluminum, titanium and silicon carbide/aluminum fittings. Three tube/fitting attachment methods were evaluated: (1) adhesively bonded without fasteners, (2) adhesively bonded with fasteners and (3) attached with fasteners without adhesive. 76 mm (3 in.) diameter tubes constructed of 393 GPa (57 MSI) and 227 GPa (33 MSI) modulus fibers in epoxy prepreg (32 plies) were used to fabricate 305 mm (12 in.) gauge length tensile specimens utilizing the three different end-fitting attachment concepts. The specimens were tested for tensile strength and stiffness in both the as-fabricated condition and after thermal cycling. A combination of adhesive bonding with fasteners produced the highest joint strengths. Author

A87-38881* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COMPOSITE TUBES FOR THE SPACE STATION TRUSS STRUCTURE

DAVID E. BOWLES and DARREL R. TENNEY (NASA, Langley Research Center, Hampton, VA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 414-429. refs

The reference configuration of NASA's Space Station includes a large truss structure to support the various modules and solar arrays. This truss structure will be constructed from tubular members approximately 2 in. in diameter and up to 23 ft in length. The important design considerations for this structure are light weight, high stiffness, dimensional stability, and long-term durability. Continuous graphite fiber reinforced polymer matrix composite materials can meet the structural requirements, and are leading candidates for the tubular truss members. However, there are concerns regarding the durability of composites during the long-term exposure to atomic oxygen and thermal cycling that will be encountered during the Space Station service life. This paper discusses space environmental factors and their effect on composite materials, and provides estimates of the changes in mechanical and thermal properties of composites exposed to long-term Space Station conditions. The effect of low velocity impact and handling damage on composite tube properties is also discussed. Author

A87-38909* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ASSESSMENT OF SPACE ENVIRONMENT INDUCED MICRODAMAGE IN TOUGHENED COMPOSITE MATERIALS

GEORGE F. SYKES, JOAN G. FUNK, and WAYNE S. SLEMP (NASA, Langley Research Center, Hampton, VA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 520-534.

The effects of simulated space environments on the microdamage in a series of commercially available toughened matrix composite systems was determined. Low-earth orbit (LEO) exposures were simulated by thermal cycling; geosynchronous orbit (GEO) exposures were simulated by electron irradiation plus thermal cycling. Material response was characterized by assessing the induced microcracking and its influence on chemical and mechanical property changes. All materials, including several advanced, tough thermoplastics microcracked when exposed to the simulated LEO environment except a 177 C cured single phase toughened epoxy composite. The GEO simulated environment produced microdamage in all materials. The results suggest that increased matrix toughness may not be the overriding factor leading to improved durability in the space environment. Author

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COMPOSITE SPACE ANTENNA STRUCTURES - PROPERTIES AND ENVIRONMENTAL EFFECTS

C. A. GINTY (NASA, Lewis Research Center, Cleveland, OH) and N. M. ENDRES (Sverdrup Technology, Inc., Middleburg Heights, OH) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 545-560. Previously announced in STAR as N87-16880. refs

The thermal behavior of composite spacecraft antenna reflectors has been investigated with the integrated Composites Analyzer (ICAN) computer code. Parametric studies have been conducted on the face sheets and honeycomb core which constitute the sandwich-type structures. Selected thermal and mechanical properties of the composite faces and sandwich structures are presented graphically as functions of varying fiber volume ratio, temperature, and moisture content. The coefficients of thermal expansion are discussed in detail since these are the critical design parameters. In addition, existing experimental data are presented and compared to the ICAN predictions. Author

A87-38912

MEASURING THERMAL EXPANSION IN LARGE COMPOSITE STRUCTURES

GARY C. KRUMWEIDE, DAVID N. CHAMBERLIN, and EDDY A. DERBY (Composite Optics, Inc., San Diego, CA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 572-582.

A unique laser/comparator measurement method is successfully adapted to the determination of the end-to-end coefficient of thermal expansion of a large telescope metering structure. Used principally for small coupon thermal expansion measurements, this light beam and movable optics technique has been scaled up to permit measurement of the actual structure to a resolution of 10 to the -7th in/in/deg F. Also discussed is real time design/analysis support during the test program to correct test set-up design problems and to modify the design of the telescope metering structure as indicated by test results. Author

A87-38824#

APPLICATION OF REANALYSIS TECHNIQUES IN DYNAMIC ANALYSIS OF SPACECRAFT STRUCTURES

F. H. CHU and P. WALKER (RCA/Astro Electronics, Princeton, NJ) IN: Reanalysis of structural dynamic models; Proceedings of the Symposium, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 95-104. refs

This paper demonstrates some useful applications of reanalysis techniques to spacecraft structure design. The applications include prediction of the dynamic effects of stiffness and mass changes, optimization of structures subjected to frequency constraints, and model refinement based on modal test data. Software has been developed to integrate the reanalysis formulation with the general purpose finite element software NASTRAN. The time savings and accuracy of the approach is illustrated using a spacecraft, a space truss, and a reflector finite element model as test cases. Author

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CONTROL OF FLEXIBLE STRUCTURES BY APPLIED THERMAL GRADIENTS

DONALD L. EDBERG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 877-883. refs

Thermal, elastic, and feedback analyses are applied to the case of a beam with a distributed thermal actuator. The actuator is capable of producing a thermal gradient across the section of the beam. One candidate for such an actuator uses the Peltier effect, which appears in certain semiconductors. These devices act as heat pumps when a voltage is applied, causing a temperature gradient. It is shown that the thermal gradients can induce deflection in the beam. If the thermal gradients are applied in the proper sense to a vibrating beam, it is possible to increase the vibration damping exhibited by the structure. Experimental results are given for a cantilever beam, whose first vibrational mode damping ratio was increased from 0.81 to 7.4 percent with simple lead compensation. Author

A87-40075#

INCORPORATION OF THE EFFECTS OF MATERIAL DAMPING AND NONLINEARITIES ON THE DYNAMICS OF SPACE STRUCTURES

E. F. CRAWLEY and K. J. O'DONNELL (MIT, Cambridge, MA) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 415-420. refs

A procedure is presented for incorporating the distributed material damping effects and discrete nonlinear joint properties of truss structures into a linear analysis technique. A testing apparatus has been constructed which measures the transient response of a truss member in free-fall in a vacuum to obtain its material damping characteristics. The force-state mapping technique is presented for identifying localized nonlinearities in joints by presenting the force transmitted through the joint as a function of the full mechanical state of the joint. The nonlinear structural parameters are then linearized using an equivalent energy approach which finds the equivalent linear stiffness and linear viscous damping of each nonlinearity by equating the integrated average of the work done and energy dissipated by the nonlinearity to those of a spring and damper undergoing sinusoidal motion. Incorporation of both the distributed material damping and localized nonlinear effects is discussed in the context of forming a linearized damped finite element model. Author

A87-40866#

GRADIENT-BASED COMBINED STRUCTURAL AND CONTROL OPTIMIZATION

DAVID F. MILLER and JAEDONG SHIM (Wright State University, Dayton, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 291-298. Previously cited in issue 07, p. 938, Accession no. A86-19736. refs
(Contract F33615-84-C-3217)

A87-41052

MODELING, STABILIZATION AND CONTROL OF SERIALLY CONNECTED BEAMS

G. CHEN, A. M. KRALL (Pennsylvania State University, University Park), M. C. DELFOUR (Montreal, Universite, Canada), and G. PAYRES (Sherbrooke, Universite, Canada) SIAM Journal on Control and Optimization (ISSN 0363-0129), vol. 25, May 1987, p. 526-546. refs
(Contract NSERC-A-8730; NSF DMS-84-01297;
AF-AFOSR-85-0253; CDC-24ST-36001-3-1898)

Many flexible structures consist of a large number of components coupled end to end in the form of a chain. In this paper, consideration is given to the simplest type of such structures which is formed by N serially connected Euler-Bernoulli beams, with N actuators and sensors co-located at nodal points. When these N beams are strongly connected at all intermediate nodes and their material coefficients satisfy certain properties, uniform exponential stabilization can be achieved by stabilizing at one end point of the composite beam. Finite elements are used to discretize the partial differential equation and compute the spectra of these boundary damped operators. Numerical results are also illustrated. Author

A87-41159*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIENCES WITH THE LANCZOS METHOD ON A PARALLEL COMPUTER

SUSAN W. BOSTIC (NASA, Langley Research Center, Hampton, VA) and ROBERT E. FULTON (Georgia Institute of Technology, Atlanta) ASME, International Computers in Engineering Conference and Exhibition, New York, Aug. 9-13, 1987, Paper. 9 p. refs

A parallel computer implementation of the Lanczos method for the free-vibration analysis of structures is considered, and results for two example problems show substantial time-reduction over the sequential solutions. The major Lanczos calculation tasks are subdivided into subtasks, and parallelism is introduced at the subtask level. A speedup of 7.8 on eight processors was obtained for the decomposition step of the problem involving a 60-m three-longeron space mast, and a speedup of 14.8 on 16 processors was obtained for the decomposition step of the problem involving a blade-stiffened graphite-epoxy panel. R.R.

A87-41574

A FORMULATION FOR STUDYING DYNAMICS OF N CONNECTED FLEXIBLE DEPLOYABLE MEMBERS

A. M. IBRAHIM and V. J. MODI (British Columbia, University, Vancouver, Canada) (IAF, International Astronautical Congress on Space: New Opportunities for all People, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, p. 151-164.
(Contract NSERC-G-1547)

A relatively general formulation for studying dynamics of a system, consisting of N connected flexible deployable members (beams, plates, shells, membranes, strings) forming a topological tree or a closed configuration, is presented. The mathematical description of the system can be, in general, a combination of discrete and distributed coordinates. Joints, elastic and dissipative, permit relative rotation and translation between bodies. The elastic deformations (lateral, axial, and torsional) can be discretized using admissible functions, finite elements or lumped mass method. Rotations of the members, as well as of the entire system, can be described using a set of orientation angles, Euler parameters or Rodrigues vectors. The formulation accounts for: the presence of momentum or reaction wheels (gimballed or fixed); thrusters distributed over the flexible and rigid portions; and any prescribed forms of energy dissipation mechanisms. Of course, the generalized forces can simulate desired environmental effects. The formulation is valid for orbiting as well as ground based and marine systems. Application of the formulation is illustrated through several examples, in spacecraft dynamics, which are of contemporary interest. Author

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DYNAMIC ANALYSIS AND EXPERIMENT METHODS FOR A GENERIC SPACE STATION MODEL

W. KEITH BELVIN (NASA, Langley Research Center, Hampton, VA) and HAROLD H. EDIGHOFFER (Edighoffer, Inc., Newport News, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 10-18) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, May-June 1987, p. 270-276. Previously cited in issue 18, p. 2617, Accession no. A86-38886. refs

A87-42678*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

INTERDISCIPLINARY ANALYSIS PROCEDURES IN THE MODELING AND CONTROL OF LARGE SPACE-BASED STRUCTURES

PAUL A. COOPER (NASA, Langley Research Center, Hampton, VA), ALAN E. STOCKWELL, and ZEEN C. KIM (PRC Kentron, Inc., Hampton, VA) ASME, Symposium on Engineering Data Management: Critical Issues, New York, Aug. 10-14, 1987, Paper. 10 p.

The paper describes a computer software system called the Integrated Multidisciplinary Analysis Tool, IMAT, that has been developed at NASA Langley Research Center. IMAT provides researchers and analysts with an efficient capability to analyze satellite control systems influenced by structural dynamics. Using a menu-driven interactive executive program, IMAT links a relational database to commercial structural and controls analysis codes. The paper describes the procedures followed to analyze a complex satellite structure and control system. The codes used to accomplish the analysis are described, and an example is provided of an application of IMAT to the analysis of a reference space station subject to a rectangular pulse loading at its docking port. Author

A87-44588

PEEK (POLYETHER ETHER KETONE) WITH 30 PERCENT OF CARBON FIBRES FOR INJECTION MOLDING

PAUL HEBRARD and MICHEL PARCELIER (Aerospatiale, Division Systemes Balistiques et Spatiaux, Les Mureaux, France) IN: High tech - The way into the nineties; Proceedings of the Seventh International SAMPE Conference, European Chapter, Munich, West Germany, June 10-12, 1986 . Amsterdam and New York, Elsevier Science Publishers, 1986, p. 187-200. refs

Carbon-fiber-reinforced PEEK injected-mold composites have been developed which reduce weight and cost while optimizing mechanical properties and improving the dimensional stability of injection molding conditions. Attention is presently given to the influence of thermal posttreatment of the resin and the effect of its crystallinity on such aspects of long-term behavior as creep and fatigue properties. The method in question is used to produce a prototype nozzle for a deployable antenna mast, and the various difficulties encountered are discussed. O.C.

A87-46793*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

AN APPROACH TO STRUCTURE/CONTROL SIMULTANEOUS OPTIMIZATION FOR LARGE FLEXIBLE SPACECRAFT

JUNJIRO ONODA and RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 25, Aug. 1987, p. 1133-1138. refs

(Contract NAG1-224)

This paper presents an approach to the simultaneous optimal design of a structure and control system for large flexible spacecrafts based on realistic objective function and constraints. The weight or total cost of structure and control system is minimized subject to constraints on the magnitude of response to a given disturbance involving both rigid-body and elastic modes. A nested optimization technique is developed to solve the combined problem. As an example, simple beam-like spacecraft under a steady-state white-noise disturbance force is investigated and some results of optimization are presented. In the numerical examples, the stiffness distribution, location of controller, and control gains are optimized. Direct feedback control and linear quadratic optimal controls laws are used with both inertial and noninertial disturbing force. It is shown that the total cost is sensitive to the overall structural stiffness, so that simultaneous optimization of the structure and control system is indeed useful. Author

A87-47327

EVALUATION OF THE BUILT-IN STRESSES AND RESIDUAL DISTORTIONS ON CURED COMPOSITES FOR SPACE ANTENNA REFLECTORS APPLICATIONS

M. MARCHETTI, S. TIZZI (Roma I, Universita, Rome, Italy), and F. MORGANTI (Selenia Spazio S.p.A., Rome, Italy) Composite Structures (ISSN 0263-8223), vol. 7, no. 4, 1987, p. 267-283. Research supported by the Ministero della Pubblica Istruzione. refs

Manufacturing and thermal distortion RMS is an important dimensional parameter which can be correlated with the antenna performances. For this reason it is used to characterize their allowed dimensional stability in order to guarantee the mission requirements. The antenna reflectors on board of space platforms are generally manufactured with composite materials. The RMS of these structures is very tightly connected with the technologies like curing cycles, kind of materials, lay up tipology, mould configuration etc. The maximum effort is produced to minimize this parameter due to the manufacturing, while the prediction methods able to correlate the residual distortions versus the applied technology can be very useful to optimize the hardware performances. Author

A87-47909*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EFFECTS OF ATMOSPHERE ON SLEWING CONTROL OF A FLEXIBLE STRUCTURE

JER-NAN JUANG and LUCAS G. HORTA (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 613-620) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, July-Aug. 1987, p. 387-392. Previously cited in issue 18, p. 2618, Accession no. A86-38942. refs

A87-47912*# California Univ., Los Angeles.

PERTURBATION ANALYSIS OF INTERNAL BALANCING FOR LIGHTLY DAMPED MECHANICAL SYSTEMS WITH GYROSCOPIC AND CIRCULATORY FORCES

P. A. BLELLOCH, D. L. MINGORI, and J. D. WEI (California, University, Los Angeles) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, July-Aug. 1987, p. 406-410. refs

(Contract NAS7-918)

Approximate expressions are developed for internally balanced singular values corresponding to the modes of mechanical systems with gyroscopic forces, light damping, and small circulatory forces. A brief overview is first given of the balanced realization model reduction method, including a discussion of recent work. The models considered are defined, and a perturbation analysis is used to show that the modal representation becomes asymptotically balanced as damping reduces to zero. The approximate balanced singular values are calculated, and a simple example of a flexible, dual-spin spacecraft is given as an illustration of the results. C.D.

A87-48341

A BASIS CHANGE STRATEGY FOR THE REDUCED GRADIENT METHOD AND THE OPTIMUM DESIGN OF LARGE STRUCTURES

K. T. JOSEPH (Indian Space Research Organization, Vikram Sarabha, Space Centre, Trivandrum, India) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 24, July 1987, p. 1269-1281. refs

The paper proposes a basis change strategy within the reduced gradient method for optimization under linear constraints. It ensures a nonsingular basis matrix at every iteration. The same strategy can reliably be used within the generalized reduced gradient method for optimization under nonlinear constraints. This method is applied to the minimum weight design of large structures under displacement and stress constraints, exploiting the sparsity of the constraint Jacobian matrix. Author

A87-48714#

FLEXIBILITY EFFECTS - ESTIMATION OF THE STIFFNESS MATRIX IN THE DYNAMICS OF A LARGE STRUCTURE

M. L. AMIROUCHE (Illinois, University, Chicago) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 109, July 1987, p. 283-288. refs

In this paper, an estimation of the stiffness matrix for a mechanical tree-like structure is presented. The coefficients of the stiffness matrix are evaluated based on Kane's equations together with the finite segment modeling technique and matrix structure analysis. The procedure developed is used to evaluate the stiffness coefficients in the case where the flexibility effects are modeled by uniform beam elements with springs and dampers at the connecting joints. The method presented in this paper is very useful in the study of the dynamics, vibration, and control of a large tree-like structuure undergoing large motions. An illustration of how the method is used in extracting the natural frequencies and their corresponding mode shapes is presented. The set of equations developed in this paper are the complement equations used to monitor the transient response of the structure undergoing a rigid-body motion. Author

A87-50232

ACTIVE VIBRATION CONTROL OF A SIMPLY SUPPORTED BEAM USING A SPATIALLY DISTRIBUTED ACTUATOR

SHAWN E. BURKE and JAMES E. HUBBARD, JR. (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Aug. 1987, p. 25-30. Research supported by the Charles Stark Draper Laboratory, Inc. refs

The application of a spatially shaped distributed actuator to the vibration control of a simply supported beam is studied analytically and experimentally with reference to component elements used in large space structures. The actuator consists of a layer of PVF2 bonded to one face of the beam; the requisite film controller has a linearly varying spatial distribution which facilitates the control of both even-order and odd-order vibrational modes, serving to increase the modal loss factors by up to a factor of 4.5. The experimental results are found to corroborate a simplified computer model of the controller. B.J.

A87-50416*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ROBUST EIGENSYSTEM ASSIGNMENT FOR FLEXIBLE STRUCTURES

JER-NAN JUANG, KYONG B. LIM (NASA, Langley Research Center, Hampton, VA), and JOHN L. JUNKINS (Texas A&M University, College Station) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 117-123. refs
(AIAA PAPER 87-2252)

An improved method is developed for eigenvalues and eigenvectors placement of a closed-loop control system using either state or output feedback. The method basically consists of three steps. First, the singular value of QR decomposition is used to generate an orthonormal basis that spans admissible eigenvector space corresponding to each assigned eigenvalue. Secondly, given a unitary matrix, the eigenvector set which best approximates the given matrix in the least-square sense and still satisfy eigenvalue cosntraints is determined. Thirdly, a unitary matrix is sought to minimize the error between the unitary matrix and the assignable eigenvector matrix. For use as the desired eigenvector set, two matrices, namely, the open-loop eigenvector matrix and its closest unitary matrix are proposed. The latter matrix generally encourages both minimum conditioning and control gains. In addition, the algorithm is formulated in real arithmetic for efficient implementation. To illustrate the basic concepts, numerical examples are included. Author

A87-50442#

ACTIVE DAMPING CONTROL DESIGN FOR THE COFS MAST FLIGHT SYSTEM

FREDRIC M. HAM, BEN L. HENNIGES, and SCOTT W. GREELEY (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 354-360.
(AIAA PAPER 87-2321)

Design and development of the Mast Flight System for the COFS (Control of Flexible Structures) program for NASA is currently underway. An active damping controller is required to provide five percent damping for the first ten structural modes of a sixty meter truss beam structure. The baseline control system to provide the required damping is a Positive-Real Decentralized Velocity Feedback (PRDVF) type. Continuous and discrete time designs are presented. The system modeling details are also presented which includes the models for the truss beam and the colocated actuators and sensors. Author

A87-50443#

ACTIVE VIBRATION CONTROL SYNTHESIS FOR THE COFS-I - A CLASSICAL APPROACH

BONG WIE (Texas, University, Austin) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 361-369. refs
(AIAA PAPER 87-2322)

The major findings of a Guest Investigator study of the active vibration control for the NASA Control of Flexible Structures experiment I (COFS-I) are reported. The COFS-I flight structure is briefly characterized; the classical transfer-function approach employed is explained; and consideration is given to pole-zero modeling, proof-mass actuator dynamics, the effect of microprocessor computational delay, a generalized nonminimum-phase structural filtering concept using the noncolocated actuator/sensor. Diagrams and graphs are provided. T.K.

A87-50444#

SUBOPTIMAL FEEDBACK VIBRATION CONTROL OF A BEAM WITH A PROOF-MASS ACTUATOR

W. D. PILKEY (Virginia, University, Charlottesville) and H. POLITANSKY IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 370-378. USAF-supported research. refs
(AIAA PAPER 87-2323)

A clamped-free beam, damped by a proof-mass actuator, is selected for small scale model research of flexible structures in space. The dynamic behavior of this system is strongly influenced by the constraints on the motion of the proof-mass and by the maximum control forces available. An optimal solution is presented, using a linear programming algorithm. Then, a simplified feedback control is utilized, based on modern control theory, to obtain optimal low-frequency performance, and classical control theory to bound the high-frequency modes. By special consideration of the constraints, satisfactory control is achieved, even in the nonlinear region when the proof-mass approaches its stops. Author

A87-50445#

CONTROL OF MULTIPLE-MIRROR/FLEXIBLE-STRUCTURES IN SLEW MANEUVERS

E. BARBIERI, S. YURKOVICH, and U. OZGUNER (Ohio State University, Columbus) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 379-388. refs
(AIAA PAPER 87-2324)

Modeling and control of multiple-mirror/flexible slewing structures is considered. Primary applications for such systems include Line-Of-Sight (LOS) pointing systems on large flexible structures, space telerobotic systems, and space telescope systems. Two stages characterize the modeling problem for this study: (1) the description of the rigid slewing motion and associated mirror and ray optics; and (2) the description of the flexible dynamics. The rigid-motion ray-trace equations are developed by using the compact notation used to describe the motion of robotic manipulators, while flexible dynamics are obtained via standard finite-element techniques. The resulting hybrid model is suitable for analysis in a four stage process: (1) relegation of control tasks (intimately related to the kinematics); (2) the standard slewing control problem; (3) flexibility compensation using mirror actuators; and (4) active vibration damping with additional (proof-mass) actuation. In the present paper the first and third stages of the above process are addressed. An example structure is examined, and control simulations are included for an experimental set-up being developed consisting of a 3-mirror and flexible/slewing beam system. Author

A87-50446#

A LABORATORY SIMULATION OF FLEXIBLE SPACECRAFT CONTROL

J. A. BOSSI (Boeing Aerospace Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 389-394.
(AIAA PAPER 87-2325)

A low-cost test structure, including low-frequency lightly-damped modes, some of which have nearly identical frequencies, has been constructed for simulation of some of the control problems expected to arise with large flexible spacecraft. The test structure, floating freely on a flat air-bearing table, combines translational and rotational rigid-body modes with flexible modes. Closed-loop control of the test structure is made possible using discrete displacement measurements, digital control, and pulsed actuation. Preliminary results on flexible mode control are presented, and the spacecraft control simulator is found to be useful in gaining laboratory experience with multivariable control design methods. R.R.

A87-50471*# Old Dominion Univ., Norfolk, Va.

SINGLE-MODE PROJECTION FILTERS FOR IDENTIFICATION AND STATE ESTIMATION OF FLEXIBLE STRUCTURES

JEN-KUANG HUANG, CHUNG-WEN CHEN (Old Dominion University, Norfolk, VA), and JER-NAN JUANG (NASA, Langley Research Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 595-604. refs
(Contract NAG1-655)
(AIAA PAPER 87-2387)

Single-mode projection filters are developed for eigensystem parameter identification and state estimation from both analytical results and test data. Explicit formulations of these projection filters are derived using the pseudoinverse matrices of the controllability and observability matrices in the general sense. A global minimum optimization algorithm is developed to update the filter parameters by using the interval analysis method. Modal parameters can be identified and updated in the global sense within a specified region of parameters by passing the experimental data through the projection filters. For illustration of this new approach, a numerical example is shown by using a one-dimensional global optimization algorithm to estimate modal frequencies and damping. Author

A87-50473#

SQUARE ROOT STATE ESTIMATOR FOR LARGE SPACE STRUCTURES

YAAKOV OSHMAN and DANIEL J. INMAN (New York, State University, Buffalo) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 617-627. refs
(AIAA PAPER 87-2389)

A square root Kalman filtering algorithm is developed for large space structures, which are modeled by second-order continuous-time finite dynamic models augmented by a discrete-time measurement process. The algorithm is based on the spectral decomposition of the estimation error covariance matrix into its V-Lambda factors, where V is the matrix whose columns are the covariance eigenvectors and Lambda is the diagonal matrix of eigenvalues. The filter consists of a continuous time-update stage and a discrete measurement update stage. In the time-update stage a weighted eigenvector matrix is used instead of using V directly, to avoid the inversion of the mass matrix during the numerical integration process. The measurement update is based on the Singular Valve Decomposition technique. Using the orthogonality property of the covariance eigenvectors, an orthogonalization step is optionally added at the exit from the time-update stage to enhance the filter accuracy. Author

A87-50502#

A NEW CONCEPT OF GENERALIZED STRUCTURAL FILTERING FOR ACTIVE VIBRATION CONTROL SYNTHESIS

BONG WIE and KUK WHAN BYUN (Texas, University, Austin) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 919-929. refs
(AIAA PAPER 87-2456)

A new concept of generalized structural filtering and its application to active vibration control synthesis are presented. The concept is a natural extension of the classical notch and phase lead/lag filtering, and emphasizes the use of a nonminimum-phase filter which has zeros in the right-half s-plane. Application of this concept to single-input/single-output systems with many oscillatory modes results in a robust feedback compensator with much physical insight. The concept also enables the control designer to understand the inherent nature of an 'optimal' compensator, and to modify the optimal design to be more robust and meaningful. This paper shows that for certain cases, nonminimum-phase structural filtering provides the proper phase-lag to increase the closed-loop damping of the flexible modes, while maintaining good performance and robustness to parameter variations. Author

A87-50504#

ADAPTIVE IDENTIFICATION OF FLEXIBLE STRUCTURES BY LATTICE FILTERS

FARYAR JABBARI (California, University, Irvine) and J. S. GIBSON (California, University, Los Angeles) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 941-949. refs
(Contract AF-AFOSR-84-0309)
(AIAA PAPER 87-2458)

Recent investigations on lattice filters, and their applications to adaptive identification of flexible structures, are presented. Since the order of the systems cannot be known -or the effective order may change- the order recursiveness of the lattices is of particular interest. Implementation of lattices would permit on-line order determination and would allow the order of the filter to be changed without the need to reprocess the previous data. Experimental data from the flexible grid structure at NASA-Langley are used to obtain results showing the feasibility of lattices and the advantages that result from their order recursive property. One-step-ahead prediction and estimates for natural frequencies are among the results shown. Of particular interest are the frequency estimates which agree closely with the frequency estimates obtained from off-line identification techniques. The one step-ahead prediction results also show the advantages that lattices provide with their order-determination capability, which would be significant for adaptive control purposes. Author

A87-50506*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DISTRIBUTED PARAMETER MODELING OF THE STRUCTURAL DYNAMICS OF THE SOLAR ARRAY FLIGHT EXPERIMENT

L. W. TAYLOR, JR. and J. L. WILLIAMS (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 959-974. refs
(AIAA PAPER 87-2460)

A distributed-parameter model of the structural dynamics of the space-shuttle-deployed Solar Array Flight Experiment is developed and used to produce estimates of the modal frequencies and mode shapes. A lumped parameter version of the distributed model is used to estimate model characteristics by analyzing the measured responses of 32 targets. To make the modeling more tenable, a distributed parameter system is used to reduce the number of unknown parameters, a modified Newton-Raphson technique is used for rapid convergence, and a parallel processing supercomputer is used for more efficient computation. The performances of computers with a high-speed serial processor and with a high-speed parallel processor are compared. The best results are obtained with the modeling approach in which maximum likelihood estimation is applied to distributed parameter models. R.R.

A87-50507#

PRACTICAL ISSUES IN COMPUTATION OF OPTIMAL, DISTRIBUTED CONTROL OF FLEXIBLE STRUCTURES

W. H. BENNETT (Systems Engineering, Inc., Greenbelt, MD) and H. G. KWATNY (Drexel University, Philadelphia, PA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 975-987. refs
(Contract F49620-84-C-0115)
(AIAA PAPER 87-2461)

The computation of optimal, distributed state feedback control laws for continuum models arising in flexible space structures is considered. Practical issues are discussed relating to a computational procedure which does not necessarily employ modal or finite element methods for reduced-order modeling as an essential part of the computations. Instead, the frequency response of the distributed parameter system is sampled. The method for computing optimal control laws is based on a Wiener-Hopf problem whose solution involves the solution of an irrational spectral factorization problem. Effective numerical algorithms are discussed and a simple example is given which serves to illustrate the method and some numerical sensitivities associated with the evaluation of certain transcendental terms arising in the frequency response computations. Author

A87-51793

DEVELOPMENT OF FULL SCALE DEPLOYABLE CFRP TRUSS FOR SPACE STRUCTURE

YOSHIAKI SAKATANI and TETSUYA YAMAMOTO (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Japan) IN: Composites '86: Recent advances in Japan and the United States; Proceedings of the Third Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 23-25, 1986 . Tokyo, Japan Society for Composite Materials, 1986, p. 693-700.

A design development program has been conducted for deployable truss structures that may serve as spacecraft platforms, antennas, or solar cell panels. The CFRP composite structural elements investigated as bases of these structures encompass hinged, sliding, and flexibly deformable types. The design chosen for structural performance testing employs CFRP tubing, bundled CFRP cable, and titanium alloy hub fittings. Attention is given to prospective synthetic aperture radar, solar cell panel, and sensor mast applications. O.C.

A87-52966#

IDENTIFICATION OF LARGE SPACE STRUCTURES - A FACTORIZATION APPROACH

TREVOR WILLIAMS (Kingston Polytechnic, Kingston-upon-Thames, England) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p.296-302) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Sept.-Oct. 1987, p. 466-473. SERC-supported research. Previously cited in issue 23, p. 3426, Accession no. A86-47432. refs

N87-20307*# Purdue Univ., West Lafayette, Ind. School of Technology.

USE OF LIGHTWEIGHT COMPOSITES FOR GAS PAYLOAD STRUCTURES

MARK B. SPENCER *In* NASA. Goddard Space Flight Center The 1986 Get Away Special Experimenter's Symposium p 31-34 Feb. 1987
Avail: NTIS HC A11/MF A01 CSCL 11D

A key element in the design of a small self-contained payload is the supporting structure. This structure must support the experiments and other components while using as little space and weight as possible. Hence, the structure material must have characteristics of being both strong and light. Aluminum was used for the structure on the first Purdue University payload, but consumed a relatively large percentage of the total payload weight. The current payload has a larger power supply requirement than did the previous payload. To allow additional weight for the batteries, a composite material has been chosen for the structure which has the required strength while being considerably lighter than aluminum. A radial fin design has been chosen for ease of composite material lay-up and its overall strength of design. A composite plate will connect the free ends of the fins and add strength and reduce vibration. The physical characteristics of the composite material and the method of open lay-up construction is described. Also discussed are the testing, modifications, and problems encountered during assembly of the experiments to the structure. Author

N87-20347 Massachusetts Univ., Amherst.

DYNAMIC AND THERMAL EFFECTS IN VERY LARGE SPACE STRUCTURES Ph.D. Thesis

RAMESH-BABU MALLA 1986 326 p
Avail: Univ. Microfilms Order No. DA8701196

A mathematical formulation was developed for an axially flexible structure executing a planar motion in a general orbit in space in order to determine dynamic and thermal effects in the structure due to various disturbances in a space environment. The characteristic dimension of the structure is very large (of the order of a few kilometers). The influences of the differential gravitational forces, the radiation heating, and the radiation pressure forces were studied. Effects of these factors were studied on the structure's axial deformation, its attitude motion and its orbit simultaneously. Results are obtained for various initial conditions and physical parameter values. It is observed that the differential gravitational forces do not have any appreciable effects on the structure's axial length and its attitude motion. Thermal effects are significant in producing appreciable structural deformation, and they also affect the attitude motion of the structure considerably. The radiation pressure forces are very significant in changing attitude motion of the space structure, but it causes negligible effects in producing longitudinal deformation of the structure. All of the above factors have insignificant effects on the orbit of the structure chosen in this study. Of all the three external disturbances, the radiation pressure forces are found to be strongest in affecting the orbit of the structure. Dissert. Abstr.

N87-20348 Georgia Inst. of Tech., Atlanta.
STUDIES IN NONLINEAR STRUCTURAL DYNAMICS: CHAOTIC BEHAVIOR AND POYNTING EFFECT Ph.D. Thesis
NANDAKISHOR SADASHIV ABHYANKAR 1986 237 p
Avail: Univ. Microfilms Order No. DA8628350

Nonlinear structural dynamics is one of the interdisciplinary fields used to predict and control the vibration of large space structures and flexible bodies. Transient response and steady state vibration constitute two integral parts of the field of structural dynamics. Specific problems consisting of the dynamic coupling of torsional and extensional deformations of a circular cylindrical bar and the chaotic forced vibration of buckled beams are addressed. Equations governing torsional and extensional coupling of waves for a finite hyperelastic cylindrical bar were formulated. Solutions are compared with available exact solutions. The period doubling and chaotic motion were studied for a simply supported buckled beam excited with periodic forcing function. The partial differential equations were solved directly by an explicit, stable finite difference scheme. Dissert. Abstr.

N87-20352*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNAS: A SYSTEMS ANALYSIS CASE HISTORY
LLOYD S. KEAFER, comp. and U. M. LOVELACE, comp. Feb. 1987 19 p
(NASA-TM-89072; NAS 1.15:89072) Avail: NTIS HC A02/MF A01 CSCL 22B

The value of systems analysis and engineering is aptly demonstrated by the work on Large Space Antennas (LSA) by the NASA Langley Spacecraft Analysis Branch. This work was accomplished over the last half-decade by augmenting traditional system engineering, analysis, and design techniques with computer-aided engineering (CAE) techniques using the Langley-developed Interactive Design and Evaluation of Advanced Spacecraft (IDEAS) system. This report chronicles the research highlights and special systems analyses that focused the LSA work on deployable truss antennas. It notes developmental trends toward greater use of CAE techniques in their design and analysis. A look to the future envisions the application of improved systems analysis capabilities to advanced space systems such as an advanced space station or to lunar and Martian missions and human habitats. Author

N87-20355# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
MECHANICAL QUALIFICATION OF LARGE FLEXIBLE SPACECRAFT STRUCTURES
Jul. 1986 269 p In ENGLISH and FRENCH Meeting held in Oberammergau, West Germany, 9-13 Sep. 1985
(AD-A175529; AGARD-CP-397; ISBN-92-835-0396-1) Avail: NTIS HC A12/MF A01

An account is given of Conference Proceedings of a Specialists' Meeting held by the Structures and Materials Panel in Oberammergau in the Fall of 1985. The problems associated with the mechanical qualification of flexible spacecraft are discussed, and details of relevant methods and techniques are given. The final discussion highlights the difficulties associated with advanced methods of experimental and theoretical dynamic analysis and the handling of larger and larger amounts of data.

N87-20358# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DYNAMIC MODELING AND OPTIMAL CONTROL DESIGN FOR LARGE FLEXIBLE SPACE STRUCTURES
L. PASSERON, CH. GARNIER, and B. SEVENNEC *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 14 p Jul. 1986
Avail: NTIS HC A12/MF A01

Some advanced results in dynamic modeling and control areas are unifyingly reviewed. Dynamic modeling for complex assemblies of interconnected, rigid or flexible bodies subject to wide relative motions is achieved through a Lagrangian formulation using quasi-coordinates. Lagrange multipliers are explicitly eliminated by way of singular value decomposition resulting in a minimized set of equations. An original software program using element shape functions interfaces the dynamic model with NASTRAN-performed individual substructure analyses. Section 3 summarizes the now classical results in optimal control, while section 4 gives a comprehensive coverage of robustness aspects. Last section is devoted to model order reduction. The Internal Balancing Approach is generalized to systems with rigid body modes. Moreover, an error bound between full order and reduced order transfer function is evidenced, which bridges truncation and robustness. Author

N87-20361*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRUCTURAL QUALIFICATION OF LARGE SPACECRAFT
BEN K. WADA *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 19 p Jul. 1986
Avail: NTIS HC A12/MF A01 CSCL 22A

Over the past twenty-five (25) years of the space program, the major challenge in the structural qualification of the primary structure has shifted from conducting a test that simulated the environment to accurately predicting the structural member loads in flight. Once the flight loads are available, a number of different test methods are used to qualify the structure by subjecting it to the proper loads. The qualification challenge for future large spacecraft will be to adequately predict its dynamic characteristic in space to assure that it can be controlled to meet the mission objectives. A new test concept that may allow acquisition of modal data by ground tests for verification of mathematical models of large flexible space structures which can't be ground tested by conventional methods is discussed. Author

N87-20362# Rome Univ. (Italy). Dipt. Aerospaziale.
EFFECT OF MODAL DAMPING IN MODAL SYNTHESIS OF SPACECRAFT STRUCTURES
LUIGI BALIS CREMA and ANTONIO CASTELLANI *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 11 p Jul. 1986
Avail: NTIS HC A12/MF A01

In the modal synthesis of a large space structure, by a substructuring approach, a focal point is in the evaluation of the modal characteristics of the single components. As a matter of fact it is required to get the non-diagonal terms of the damping substructure matrix to acquire an efficient estimate of the damping characteristics of the whole structure. In this work it has been considered important to understand and to predict the physical causes of complex modes also in an elementary substructure as a sandwich carbon fiber plate. The results of the experimental work indicate that the modal analysis has to be gained in a very tight frequency range, with many averaged data, and the possibility of complex modes is increasing with the increase of the mode order. Author

N87-20363# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.
DYNAMIC QUALIFICATION OF SPACECRAFT BY MEANS OF MODAL SYNTHESIS
A. BERTRAM and P. CONRAD (Messerschmitt-Boelkow-Blohm/Entwicklungspring Nord, Bremen, West Germany.) *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 11 p Jul. 1986 Sponsored in part by ESA/ESTEC
Avail: NTIS HC A12/MF A01

The dynamic qualification process is essentially based on tests: verification tests and qualification tests. In order to render ground testing feasible, the structure has to be subdivided into modules. After performing tests on the module level, the dynamic behavior of the entire structure is obtained by modal synthesis. The experience gained in applying modal synthesis concepts to simple models and spacecraft-type structures is discussed. It is shown that the success of a modal synthesis approach is considerably dependent on the input data, i.e., the results of the modal survey tests. Accordingly, test data requirements are outlined. Finally, the discussion includes the way in which the coupling analyses can be improved by precise consideration of the coupling conditions in substructure tests and calculations. Author

N87-20364# Centre National d'Etudes Spatiales, Toulouse (France).

LOW FREQUENCY VIBRATION TESTING ON SATELLITES

A. GIRARD, A. MAMODE, and F. MERCIER *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 9 p Jul. 1986 In FRENCH; ENGLISH summary and title

Avail: NTIS HC A12/MF A01

Except the well known POGO phenomenon, the low frequency dynamic flight environment for a satellite consists of transient vibrations, mainly thrust transients. The qualification is generally achieved by a sine sweep on a shaker according to contractual specifications. Far from the POGO frequencies and near the main resonant frequencies of the satellite, notchings based on quasi static load criteria or launch vehicle/satellite coupled analysis results are applied to avoid overtesting. However this approach becomes unsatisfactory for complex structures with large appendages, where the initial specifications are widely modified, disturbing the qualification of secondary structures. In order to improve the representativity of these tests, transient vibration testing has been recently investigated. The feasability of such tests on electrodynamic shakers using digital control techniques was demonstrated several years ago and the main problem remaining prior to their operational use has been the definition of an adequate specification for satellite qualification purposes. Several approaches are presented, including shock synthesis, production of a specified transient, and simulation of the launch vehicle impedance. Author

N87-20365# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.

MODAL-SURVEY TESTING FOR SYSTEM IDENTIFICATION AND DYNAMIC QUALIFICATION OF SPACECRAFT STRUCTURES

N. NIEDBAL and H. HUENERS *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 13 p Jul. 1986

Avail: NTIS HC A12/MF A01

Modal-survey testing is an increasingly common part of the qualification procedure for spacecraft structures, since it offers an experimental verification of normal mode parameters determined by dynamic finite-element anlaysis. Moreover, it permits identification of structural damping, knowledge of which is essential for reliable flight-load calculations. A state of the art survey of modern modal-survey testing is given here, covering the phase-resonance method and various phase-separation methods. The use of modal-survey results in the dynamic qualification of spacecraft structures is discussed, emphasizing the correlation of analytical and experimental modal data. This aspect has attracted growing interest in recent years, due to the obvious need for convenient tools that allow finite-element models to be updated with measured modal data. Author

N87-20366# Spar Aerospace Ltd., Weston (Ontario).

MODAL TESTING OF THE OLYMPUS DEVELOPMENT MODEL STOWED SOLAR ARRAY

S. DRAISEY, M. ELZEKI, A. S. JONES, and G. MARKS *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 14 p Jul. 1986

Avail: NTIS HC A12/MF A01

The modal testing portion of the structural verification of the stowed solar array configuration of the Olympus S/C, a high powered communication satellite is discussed. The Olympus S/C was designed for both Ariane and Shuttle launches. This versatility of launch configurations requires an emphasis on the ability to accurately predict loads and structural performance. The stowed array is comprised of: release mechanisms, a tip tensioning mechanism, a stowed astromast and a folded flexible blanket to which solar cells have been mounted. The blanket is held in place between a pallet and pressure plate. The prediction of accurate structural response for such a complicated arrangement from analytical data only would be difficult. Over the past few years Spar has undertaken several development studies in the area of modal analysis. Within these studies a technique, using base excitation of the structure has been established. The use of base input as the excitation for a modal test has provided an economical means of incorporating a modal test into a structural acceptance test procedure. Author

N87-20367# Politecnico di Milano (Italy). Dipt. di Ingegneria Aerospaziale.

ACTIVE STRUCTURAL CONTROLLERS EMULATING STRUCTURAL ELEMENTS BY ICUS

AMALIA ERCOLI FINZI, MASSIMILIANO LANZ, and PAOLO MANTEGAZZA *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 13 p Jul. 1986

Avail: NTIS HC A12/MF A01

An approach is presented to the active control design of Large Space Structures that is based on the adoption of decentralized control units. These control units use colocated sensors and actuators and adopt a control law that generates forces proportional to local motions in order to emulate real structural elements, discrete tuning masses and grounding spring-damper combinations. Some numerical examples are used to demonstrate the application of the Independent Control Unit (ICU) concept to a beam and a plate for which the active structure controls are obtained by using a suboptimal design procedure. It is shown how the use of this type of control unit allows the development of an intrinsic fail-safe design. The results obtained with the application of the concepts developed here are demonstrated by their application to an experiment in which a thin beam, suspended from the ceiling, is controlled by different combinations of the independent analog control units making use of a velocity trasducer, an integrator and an electrodynamic actuator. Author

N87-20368# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany). Modal Testing Sect.

SPACECRAFT QUALIFICATION USING ADVANCED VIBRATION AND MODAL TESTING TECHNIQUES

K. MUEHLBAUER and U. SCHILDT *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 9 p Jul. 1986

Avail: NTIS HC A12/MF A01

The classical single-shaker vibration test has played a dominant role in the mechanical qualification of flexible spacecraft. Due to the substantially increased payload capacity of modern carrier vehicles the existing test facilities have reached their limits in terms of test article mass and size. These limits are being extended by implementing multi-shaker systems for uni-axial testing. At the same time digital data acquisition and analysis techniques are employed to get a better understanding of the test results and of the test article itself. An alternative approach which overcomes the limitations imposed by the test article size is the analytical qualification. Besides static testing this is in particular supported by modal testing accomplished on system or on sub-system level. For modal testing a broad spectrum of computerized or computer-based techniques is now available which are capable of meeting manifold requirements. The dynamic testing techniques mentioned here are outlined and illustrated using actual examples of installations and applications. Author

N87-20369# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.

INFLUENCE CO-EFFICIENT TESTING AS A SUBSTITUTE FOR MODAL SURVEY TESTING OF LARGE SPACE STRUCTURES

T. F. KEATES *In* AGARD Mechanical Qualification of Large

Flexible Spacecraft Structures 9 p Jul. 1986
Avail: NTIS HC A12/MF A01

The American Space Transportation System is capable of placing large payload into low earth orbit. Since the presence of the payload has a significant effect on the behavior of the Shuttle under the low frequency and transient loading during launch and return, a flight loads analysis is performed using a mathematical model of the payload coupled to that of the Shuttle. The process of clearing a payload for launch involves performing this coupled analysis with a validated mathematical model of the payload. This validation usually includes modal survey testing on a structurally representative model which may also be used for static load testing. The advantages and disadvantages of modal survey testing (either fixed base or free/free) and of Static Influence Co-efficient (Flexibility) Testing are discussed. It is concluded that for parts of certain types of payload the latter is a cheaper and sufficient alternative to modal survey testing. Author

N87-20372# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.

ACOUSTIC EFFECTS ON THE DYNAMIC OF LIGHTWEIGHT STRUCTURES

J. J. WIJKER *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 15 p Jul. 1986
Avail: NTIS HC A12/MF A01

The influence of the acoustic effects (surrounding air) on the dynamic behavior of lightweight structures is discussed. Emphasis is given to: the unexpected dynamic characteristics as shown during test; simulation of the acoustic loading within the finite element representation (linear domain); and comparison of the measured dynamic characteristics (modal survey) with the adapted finite element results.

N87-20374# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.

DEVELOPMENT OF PRECISION STRUCTURAL JOINTS FOR LARGE SPACE STRUCTURES

HAROLD C. CROOP and ANDREW R. ROBERTSON (General Dynamics Corp., San Diego, Calif.) *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 7 p Jul. 1986
Avail: NTIS HC A12/MF A01

Many anticipated future space systems will employ deployable structural assemblies to meet the packaging constraints of the Space transporatation System. Recent developments in deployable structures are described relative to the use of advanced composite materials in the joint designs of such systems. Specific design requirements of interest are dimensional stability, zero free play, minimum weight, and thermal/electrical conductivity through the joints. Several design approaches are presented, along with results of material characterization tests. Author

N87-20564 Virginia Polytechnic Inst. and State Univ., Blacksburg.

MODELING AND CONTROL OF FLEXIBLE STRUCTURES Ph.D. Thesis

JEFFREY KENT BENNIGHOF 1986 137 p
Avail: Univ. Microfilms Order No. DA8625796

Topics in the modeling and control of large flexible structures are examined. In the finite element convergence toward the natural modes and frequencies of a structure, it was found that two mechanisms limiting the accuracy of higher modes, are, first, a decrease in the number of active degrees of freedom for higher mode approximations due to orthogonality constraints, and, second, the fact that lower computed, rather than actual, eigenfunctions appear in the orthogonality constraints, so that inaccuracy in lower modes inhibits convergence to higher modes. Refining the elements using the hierarchial p-version proves to be far superior to refining the mesh, as demonstrated by numerical examples. A method is presented for solving the algebraic eigenvalue problem for a structure, which combines attractive features of the subspace iteration method and the component-mode synthesis methods. The effectiveness of modal control (IMSC) and direct feedback control are investigated for suppressing traveling waves on a string and on a beam, both with slight material damping. Dissert. Abstr.

N87-20567*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MODELING OF JOINTS FOR THE DYNAMIC ANALYSIS OF TRUSS STRUCTURES

W. KEITH BELVIN May 1987 43 p
(NASA-TP-2661; L-16163; NAS 1.60:2661) Avail: NTIS HC A03/MF A01 CSCL 20K

An experimentally-based method for determining the stiffness and damping of truss joints is described. The analytical models use springs and both viscous and friction dampers to simulate joint load-deflection behavior. A least-squares algorithm is developed to identify the stiffness and damping coefficients of the analytical joint models from test data. The effects of nonlinear joint stiffness such as joint dead band are also studied. Equations for predicting the sensitivity of beam deformations to changes in joint stiffness are derived and used to show the level of joint stiffness required for nearly rigid joint behavior. Finally, the global frequency sensitivity of a truss structure to random perturbations in joint stiffness is discussed. Author

N87-20568*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SPACE STATION STRUCTURES AND DYNAMICS TEST PROGRAM

CARLETON J. MOORE, JOHN S. TOWNSEND, and EDWARD W. IVEY Mar. 1987 47 p
(NASA-TP-2710; NAS 1.60:2710) Avail: NTIS HC A03/MF A01 CSCL 20K

The design, construction, and operation of a low-Earth orbit space station poses unique challenges for development and implementation of new technology. The technology arises from the special requirement that the station be built and constructed to function in a weightless environment, where static loads are minimal and secondary to system dynamics and control problems. One specific challenge confronting NASA is the development of a dynamics test program for: (1) defining space station design requirements, and (2) identifying the characterizing phenomena affecting the station's design and development. A general definition of the space station dynamic test program, as proposed by MSFC, forms the subject of this report. The test proposal is a comprehensive structural dynamics program to be launched in support of the space station. The test program will help to define the key issues and/or problems inherent to large space structure analysis, design, and testing. Development of a parametric data base and verification of the math models and analytical analysis tools necessary for engineering support of the station's design, construction, and operation provide the impetus for the dynamics test program. The philosophy is to integrate dynamics into the design phase through extensive ground testing and analytical ground simulations of generic systems, prototype elements, and subassemblies. On-orbit testing of the station will also be used to define its capability. Author

N87-20569*# Auburn Univ., Ala. Dept. of Aerospace Engineering.

INITIAL INVESTIGATIONS INTO THE DAMPING CHARACTERISTICS OF WIRE ROPE VIBRATION ISOLATORS Final Technical Report

M. A. CUTCHINS, J. E. COCHRAN, JR., K. KUMAR, N. G. FITZ-COY, and M. L. TINKER 29 Apr. 1987 89 p
(Contract NAG8-532)
(NASA-CR-180698; NAS 1.26:180698) Avail: NTIS HC A05/MF A01 CSCL 20K

Passive dampers composed of coils of multi-strand wire rope are investigated. Analytical results range from those produced by complex NASTRAN models to those of a Coulomb damping model with variable friction force. The latter agrees well with experiment. The Coulomb model is also utilized to generate hysteresis loops. Various other models related to early experimental investigations

are described. Significant closed-form static solutions for physical properties of single-and multi-strand wire ropes are developed for certain specific geometries and loading conditions. NASTRAN models concentrate on model generation and mode shapes of 2-strand and 7-strand straight wire ropes with interfacial forces.
Author

N87-20574# Shock and Vibration Information Center (Defense), Washington, D. C.
THE SHOCK AND VIBRATION BULLETIN. PART 1: WELCOME, INVITED PAPERS, SHIPBOARD SHOCK, BLAST AND GROUND SHOCK, SHOCK TESTING AND ANALYSIS
Aug. 1986 297 p Proceedings of the 56th Shock and Vibration Symposium, Monterey, Calif., 22-24 Oct. 1985
(AD-A175224; SVIC-BULL-56-PT-1) Avail: NTIS HC A13/MF A01

Topics addressed include: solid mechanics; shock mechanics; dynamics and control of large space structures; structural dynamic response analysis methods; shipborne shock; blast and ground shock; and shock testing and analysis.

N87-20599# Spar Aerospace Ltd., Ste-Anne-de-Bellevue (Quebec).
OPTIMIZATION OF AEROSPACE STRUCTURES SUBJECTED TO RANDOM VIBRATION AND FATIGUE CONSTRAINTS
V. K. JHA, T. S. SANKAR (Concordia Univ., Montreal, Quebec.), and R. B. BHAT *In* Shock and Vibration Information Center The Shock and Vibration Bulletin. Part 2: Modal Test and Analysis, Testing Techniques, Machinery Dynamics, Isolation and Damping, Structural Dynamics p 193-200 Aug. 1986
Avail: NTIS HC A10/MF A01 CSCL 20K

Aerospace structures have to be designed with very strict reliability requirements, at the same time these structures should be as light as possible in weight to minimize the cost of launching into space. These structures are often subjected to random excitations with power spectral density varying in an arbitrary manner in the frequency domain. With the advent of the space shuttle, it is likely that these structures may have to be designed to withstand many launches, and hence fatigue will be an important factor along with other considerations while optimizing the design. An approach for handling and incorporating fatigue design constraints in optimizing aerospace structures is presented. Miner's criterion of cumulative fatigue damage was used to formulate the fatigue constraint to ensure that the total expected fatigue damage over the required period of fatigue life does not exceed unity. The fatigue constaint is used in conjunction with other probabilistic constraints such as those on displacements, stresses and on component sizes, when subjected to random vibration loads, to arrive at an optimum design. An optimum design of a typical satellite antenna structure was realized using the proposed approach.
Author

N87-21025# Harris Corp., Melbourne, Fla. Government Aerospace Systems Div.
OPUS: OPTIMAL PROJECTION FOR UNCERTAIN SYSTEMS Annual Report, 1 Oct. 1985 - 1 Oct. 1986
DENNIS S. BERNSTEIN Oct. 1986 354 p
(Contract F49620-86-C-0002)
(AD-A176820; AFOSR-87-0161TR) Avail: NTIS HC A16/MF A01 CSCL 22B

Increased interest in deploying large flexible spacecraft has focused attention on active structural control techniques to achieve crucial advances in vibration suppression, pointing accuracy and shape control. The extreme complexity of such systems and the lack of accurate finite-element structural models present severe control design challenges which were extensively accumulated by previous government research programs. OPUS is a rigorous new approach to this class of problems, which embodies a fundamental generalization of classical steady state linear quadratic Gaussian (LQG) optimal control theory. The present scope of the theory includes robust, reduced order modelling, estimation and control for continuous-time, discrete-time and sample data systems.
GRA

N87-21030# WEA, Cambridge, Mass.
WAVE-MODE COORDINATES AND SCATTERING MATRICES FOR WAVE PROPAGATION Technical Report, 1 Sep. 1985 - 1 Oct. 1986
JAMES H. WILLIAMS, JR., RAYMOND J. NAGEM, and HUBERT K. YEUNG 1 Oct. 1986 50 p
(Contract F49620-85-C-0148)
(AD-A176998; AFOSR-87-0021TR) Avail: NTIS HC A03/MF A01 CSCL 22B

Wave-mode coordinates and scattering matrices are discussed in conjunction with the dynamic and wave propagation analyses of large space structures. Simple one-dimensional examples are given to illustrate how wave-mode coordinates and scattering matrices may be used to describe dynamics and wave propagation in such structures.
GRA

N87-21206* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASUREMENT APPARATUS AND PROCEDURE FOR THE DETERMINATION OF SURFACE EMISSIVITIES Patent
HANS-JUERGEN C. BLUME, inventor (to NASA) 24 Feb. 1987 18 p Filed 3 Dec. 1985 Supersedes N86-24880 (24 - 15, p 2445)
(NASA-CASE-LAR-13455-1; US-PATENT-4,645,358; US-PATENT-APPL-SN-804040; US-PATENT-CLASS-374-9; US-PATENT-CLASS-250-341; US-PATENT-CLASS-374-122)
Avail: US Patent and Trademark Office CSCL 20N

A method and apparatus for independently determining the electromagnetic surface emissivity of a material is developed. This is particularly useful in the design of large deployable space antennas employing mesh membrane surfaces. The system is a closed one with respect to unwanted or uncorrelated radiation outside the system. The present embodiment comprises a radiometer connected to a horn antenna, a test section sealed to the horn antenna and a cryogenically cooled matched load (cryoload) exposed to the interior of the system. The material is enclosed in a convection test chamber within a test section, heated within a test chamber and allowed to radiate within the system such that a component of the radiation energy of the material is measured by the radiometer in terms of brightness temperature. The matched load serves as the stabilizing source of uncorrelated radiation within the system by radiating at a constant cryogenic temperature. The actual physical temperature of the material is also measured during the heating process. Brightness temperature over divided by physical temperature for the same time period is the emissivity of the material according to a derivation of the Raleigh-Jeans approximation for an ideal system free from all uncorrelated radiation.
Official Gazette of the U.S. Patent and Trademark Office

N87-21388# Systems Engineering Labs., Inc., Greenbelt, Md.
MODELING AND CONTROL OF FLEXIBLE STRUCTURES Annual Report, Oct. 1984 - Oct. 1985
W. H. BENNETT, G. L. BLANKENSHIP, and H. G. KWATNY 16 Dec. 1986 79 p
(Contract F49620-84-C-0115)
(AD-A177106; SEI-TR-86-13; AFOSR-87-0013TR) Avail: NTIS HC A05/MF A01 CSCL 20K

This report focuses on the roles of models of flexible structures in the design and evaluation of control laws for the damping of vibrational motions in those structures. The first section discusses a generic class of continuum models for flexible structures describing the abstract mathematical formulation of the models as a framework for the design of control laws. The second section shows how direct frequency domain designs for control laws may be achieved for this class of models based on a spectral factorization procedure which replaces the usual computation of Riccati equations. The third section examines the problem of deriving transfer function representations of the structural models as required in the frequency domain design procedure. Section four describes an analytical procedure for the derivation of continuum models for large scale structures with a regular infrastucture.
GRA

N87-21987*# Martin Marietta Aerospace, Denver, Colo.
NEAR-FIELD TESTING OF THE 5-METER MODEL OF THE TETRAHEDRAL TRUSS ANTENNA
NEILL KEFAUVER, TOM CENCICH, JIM OSBORN, and J. T. OSMANSKI Aug. 1986 167 p
(Contract NAS1-18016)
(NASA-CR-178147; NAS 1.26:178147; MCR-85-640) Avail: NTIS HC A08/MF A01 CSCL 22B

This report documents the technical results from near-field testing of the General Dynamics 5-meter model of the tetrahedral truss antenna at the Martin Marietta Denver Aerospace facility. A 5-meter square side of the tetrahedral served as the perimeter of the antenna, and a mesh surface and extensive surface contouring cord network was used to create a parabolic aperture shape to within an rms accuracy of 30 mils or better. Pattern measurements were made with offset feed systems radiating at frequencies of 7.73, 11.60, 2.27, and 4.26 (all in GHz). This report discusses the method of collecting the data, system measurement accuracy, the test data compiled, and diagostics and isolation of causes of pattern results. The technique of using near-field phase for measuring surface mechanical tolerances is included. Detailed far field antenna patterns and their implications are provided for all tests conducted. Author

N87-21992# WEA, Cambridge, Mass.
COMPARISON OF WAVE-MODE COORDINATE AND PULSE SUMMATION METHODS Interim Report, 1 Sep. 1985 - 1 Dec. 1986
JAMES H. WILLIAMS, JR., RAYMOND J. NAGEM, and HUBERT K. YEUNG 1 Dec. 1986 18 p
(Contract F49620-85-C-0148)
(AD-A177795; AFOSR-87-0280TR) Avail: NTIS HC A02/MF A01 CSCL 20K

Nondispersive pulse propagation in a simple one-dimensional lattice structure is analyzed using the pulse summation method and the wave-mode coordinate method. The results of the two methods are shown to be identical, and both methods account for the existence of equivalent paths in the lattice. Some recommendations for future research are given. GRA

N87-22252# Maryland Univ., College Park. Dept. of Aerospace Engineering.
DYNAMIC FINITE ELEMENT MODELING OF FLEXIBLE STRUCTURES Final Report, 1 Sep. 1985 - 23 Feb. 1986
C. S. CHOI, E. R. CHRISTENSEN, and S. W. LEE 20 Nov. 1986 39 p
(Contract AF-AFOSR-0352-85)
(AD-A177168; AFOSR-87-0165TR) Avail: NTIS HC A03/MF A01 CSCL 13M

In Part 1, reduced basis techniques are applied to the problem of the nonlinear analysis of the dynamics of unrestrained flexible structures. The reduced bases used consisted of mode shapes of the structure as well as some modal derivatives. The technique was tested on a simple spacecraft structure. The numerical results indicated that the technique did not appear very promising for this type of problem. In Part 2, a finite element technique is used for analysis of very flexible structures undergoing deployment maneuvers. The structure is assumed to consist of flexible bars attached to a rigid mass. The description of elastic deformation is based on the total Lagrangian formulation which allows finite rotation. Numerical tests demonstrates the validity of the present approach. GRA

N87-22256# WEA, Cambridge, Mass.
WAVE PROPAGATION IN TRANSVERSELY ISOTROPIC CONTINUUM MODELS OF LSS (LARGE SPACE STRUCTURES) Interim Report, 1 Sep. 1985 - 1 Jan. 1987
JAMES H. WILLIAMS, JR., RAYMOND J. NAGEM, and KARIM G. SALAME 1 Jan. 1987 35 p
(Contract F49620-85-C-0148)
(AD-A177271; AFOSR-87-0279TR) Avail: NTIS HC A03/MF A01 CSCL 20K

Continuum models of large repetitive lattice structures are often used to provide computationally efficient analyses of static, dynamic and thermomechanical properties. In this report, a continuum model is used to study wave propagation in lattice structures. Attention is focused on a tetrahedral lattice structure which may be modeled as an equivalent homogeneous transversely isotropic continuum. Numerical results for phase velocities, deviation angles, and wave front surfaces in the equivalent continuum show that wave propagation in lattice structures may be remarkably different from the more familiar wave propagation in isotropic continua. The results given here, which ignore all effects of boundaries of the lattice and which are valid for wavelengths that are long compared with the basic cell size of the lattice, are intended to give insight into how waves may propagate in large repetitive lattice structures. GRA

N87-22269# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensbereich Apparate.
STRESS AND DEFORMATION ANALYSIS OF LIGHTWEIGHT COMPOSITE STRUCTURES
KARL PFEIFER and JOERG BODE Oct. 1986 17 p Presented at the 37th International Astronautical Congress, Innsbruck, Austria, 4-11 Oct. 1986 Previously announced in IAA as A87-15939
(MBB-UD-489/86; IAF-86-212; ETN-87-99930) Avail: ISSUING ACTIVITY

The influence of thermal stress and deformation on curved beams and shells, particularly for the reflector shells of spacecraft antennas, is reviewed. It is shown that the antenna contour distortions can be minimized by thermal expansion coefficients close to zero for all parts, or be a combination of vertical and horizontal displacements which deform the whole shell within the original contour. ESA

N87-22703*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STATUS OF THE MAST EXPERIMENT
BRANTLEY R. HANKS, ANTHONY FONTANA, and JOHN L. ALLEN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 29-56 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

Many sophisticated mathematical control techniques for flexible structures have been devised. The basic problem is that most of them require a relatively accurate mathematical model of the system under control including the dynamics of both the structure and the control system components. Obtaining such a model for either subsystem traditionally has required great effort including a significant validation step based on test data. Because of the quantum increase in complexity over proven methods, promising techniques for the control of flexible structures must be validated in actual hardware experiments before committing to their use in actual spacecraft missions. The Mast experiment system serves as a focus for such validation. It is the first in a series of experiments under the Control of Flexible Structures (COFS) Program at the NASA Langley Research Center. The Mast experiment is a combination of ground tests, orbital flight test, and analysis of a deployable beam under the COFS program. It provides a vehicle for research in structures, structural dynamics, and control issues. Author

N87-22704*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE STRUCTURES GROUND EXPERIMENT CHECKOUT
HENRY B. WAITES *In its* Structural Dynamics and Control Interaction of Flexible Structures p 57-84 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

NASA Marshall Space Flight Center has developed a facility in which closed loop control of Large Space Structures (LSS) can be demonstrated and verified. The main objective of the facility is to verify LSS control system techniques so that on-orbit performance can be ensured. The facility consists of an LSS test article or payload which is connected to a 3-axis angular pointing mount assembly that provides control torque commands. The angular pointing mount assembly is attached to a base excitation system which will simulate disturbances most likely to occur for Orbiter and DOD payloads. The control computer contains the calibration software, the reference systems, the alignment procedures, the telemetry software, and the control algorithms. The total system is suspended in such a fashion that the LSS test article has the characteristics common to all LSS. Author

N87-22705*# Air Force Rocket Propulsion Lab., Edwards AFB, Calif.

IDENTIFICATION OF LARGE SPACE STRUCTURES: A STATE-OF-PRACTICE REPORT

In NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 85-98 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

An outline of this work is presented. It begins with a schematic flow diagram and a logical flow diagram of the identification process for large space structures (LSS). Next, the task is defined by a structure model definition. A matrix polynomial formulation with a node displacement equation and a state variable formulation with node displacement and velocities are outlined. Further outlined is the identification of LSS on orbit; modeling errors and uncertainties; verification and validation of model; and noise, computations, and data collection. E.R.

N87-22707*# Tennessee Univ. Space Inst., Tullahoma.

A GENERAL METHOD FOR DYNAMIC ANALYSIS OF STRUCTURES OVERVIEW

REMI C. ENGELS *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 119-132 Apr. 1987
(Contract F29601-85-K-0054)
Avail: NTIS HC A99/MF E03 CSCL 20K

The presented research deals with the development of a dynamic analysis method for structural systems. The modeling approach is essentially a finite element method in the sense that the structure is divided into n elements. An element is defined as any structural unit whose degree of freedom (dofs) can be categorized as either interface or non-interface dofs. An element could be a fundemental unit such as a rod, a beam, a plate etc., or it could be an entire structural component. Furthermore, the parameters for the element could be distributed or lumped. The choice of elements is totally arbitrary and is a matter of user convenience. In particular, issues of accuracy and convergence do not enter on the level of example that bookkeeping is reduced to a minimum. Each element is modeled using a set of interface constraint modes (ICM) combined with a set of interface restrained normal models (IRNM). The next step is the solution of the system eigenvalue problem. The procedure calls for the sequential solution of a number of small eigenvalue problems based on a truncation principle for IRNM. In addition, the form of these eigenvalue problems is very simple such that an escalator type of eigenvalue problem solver can be used which is extremely cost-effective and fast. Author

N87-22710*# Engineering Mechanics Association, Inc., Torrance, Calif.

A COMPUTER PROGRAM FOR MODEL VERIFICATION OF DYNAMIC SYSTEMS

J. D. CHROSTOWSKI and T. K. HASSELMAN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 199-214 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 09B

Dynamic model verification is the process whereby an analytical model of a dynamic system is compared with experimental data, and then qualified for future use in predicting system response in a different dynamic environment. There are various ways to conduct model verification. The approach adopted in MOVER II employs Bayesian statistical parameter estimation. Unlike curve fitting whose objective is to minimize the difference between some analytical function and a given quantity of test data (or curve), Bayesian estimation attempts also to minimize the difference between the parameter values of that function (the model) and their initial estimates, in a least squares sense. The objectives of dynamic model verification, therefore, are to produce a model which: (1) is in agreement with test data, (2) will assist in the interpretation of test data, (3) can be used to help verify a design, (4) will reliably predict performance, and (5) in the case of space structures, facilitate dynamic control. Author

N87-22712*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

VERIFICATION OF LARGE BEAM-TYPE SPACE STRUCTURES

CHOON-FOO SHIH, JAY C. CHEN, and JOHN A. GARBA *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 247-254 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

The verification approach of large beam type space structures is verified. The proposed verification approach consists of two parts. The first part is to remove the gravity effect on the tested substructure and to identify the on-orbit dynamic characteristics of the substructure by using the measurements of the ground test. A scaling law is also established to define the critical length of the structure which can be tested in 1-g field without incurring a buckling problem. The second part is to develop an adequate scaling law to extrapolate the dynamic characteristics of the prototype structure by using results from the substructure. The verification approaches are demonstrated on two typical structural configurations, the feed support structure of a wrap-rip antenna and a candidate shuttle flight experiment. The results indicate that it is practical to verify the on-orbit dynamic characteristics of these structures by using the proposed approach. Author

N87-22713*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

VERIFICATION OF FLEXIBLE STRUCTURES BY GROUND TEST

BEN K. WADA and C. P. KUO *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 255-274 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

The validation of math models of large space structures (LSS) by ground tests is attempted. Concepts for two types of LSS are presented: continuous type and linked subsystems. It was concluded that ground test which simulate space conditions are not entirely reliable, that there should be an integration of testing and analyses, which then should be validated with laboratory and flight experiments. E.R.

N87-22716*# Boeing Aerospace Co., Seattle, Wash.

FLEXIBLE SPACECRAFT SIMULATOR

In NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 399-416 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 14B

Verification of control algorithms for flexible spacecraft can be done only through simulation and test; these are necessary to understand control/structure interaction (C/SI) sufficiently to design robust controllers for future spacecraft. The objective persued is to develop a low-cost facility which simulates the fundamental problem of C/SI; and to provide accessibility for designs so that experience can be gained in applying various multivariable control design methods to an actual structure. A test facility is being constructed with test elements that provide 3 rigid body and 6 flexible modes, all in the horizontal plane, with frequencies below 2.5 Hz. The control force actuator are on/off air jets with sensing by optical displacement sensors. Loop closure is provided by a digital computer with control algorithms designed using the IAC and MATRIX-X. E.R.

N87-22719*# Auburn Univ., Ala. Dept. of Electrical Engineering.

IMPROVING STABILITY MARGINS IN DISCRETE-TIME LQG CONTROLLERS

B. TARIK ORANC and CHARLES L. PHILLIPS *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction

of Flexible Structures p 417-434 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 12A

Some of the problems are discussed which are encountered in the design of discrete-time stochastic controllers for problems that may adequately be described by the Linear Quadratic Gaussian (LQG) assumptions; namely, the problems of obtaining acceptable relative stability, robustness, and disturbance rejection properties. A dynamic compensator is proposed to replace the optimal full state feedback regulator gains at steady state, provided that all states are measurable. The compensator increases the stability margins at the plant input, which may possibly be inadequate in practical applications. Though the optimal regulator has desirable properties the observer based controller as implemented with a Kalman filter, in a noisy environment, has inadequate stability margins. The proposed compensator is designed to match the return difference matrix at the plant input to that of the optimal regulator while maintaining the optimality of the state estimates as directed by the measurement noise characteristics. Author

N87-22724*# Boeing Aerospace Co., Seattle, Wash.
DYNAMICS OF TRUSSES HAVING NONLINEAR JOINTS
J. M. CHAPMAN, F. H. SHAW, and W. C. RUSSELL *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 539-566 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

The transient analysis of trusses having nonlinear joints can be accomplished using the residual force technique. The technique was applied a two degree of freedom spring mass system, a four bay planar truss, and an actual ten bay deployable truss. Joints chosen for analysis were the nonlinear gap joints and the linear Voigt joints. Results from the nonlinear gap analyses generally indicate that coupling between the modes can display some interesting effects during free vibration. One particularly interesting effect was that the damping of the structure appeared to be higher than could be accounted for from modal damping alone. Energy transferral from the lower to the higher modes was found to exist as a result of the modal coupling. The apparently increased damping was due to the fact that the energy transferred to the higher modes is inherently dissipated more quickly. Another interesting phenomenon was that the lower modes could drive the higher modes even during free vibration and that these modes could display a rather large quasi-steady state behavior even when modal damping was present. Gaps were also found to increase the amplitude and period of the free vibration response as expected. Author

N87-22725*# Boeing Aerospace Co., Seattle, Wash.
EQUIVALENT BEAM MODELING USING NUMERICAL REDUCTION TECHNIQUES
J. M. CHAPMAN and F. H. SHAW *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 567-594 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

Numerical procedures that can accomplish model reductions for space trusses were developed. Three techniques are presented that can be implemented using current capabilities within NASTRAN. The proposed techniques accomplish their model reductions numerically through use of NASTRAN structural analyses and as such are termed numerical in contrast to the previously developed analytical techniques. Numerical procedures are developed that permit reductions of large truss models containing full modeling detail of the truss and its joints. Three techniques are presented that accomplish these model reductions with various levels of structural accuracy. These numerical techniques are designated as equivalent beam, truss element reduction, and post-assembly reduction methods. These techniques are discussed in detail. E.R.

N87-22726*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DYNAMIC CHARACTERISTICS OF A VIBRATING BEAM WITH PERIODIC VARIATION IN BENDING STIFFNESS
JOHN S. TOWNSEND *In its* Structural Dynamics and Control Interaction of Flexible Structures p 595-624 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

A detailed dynamic analysis is performed of a vibrating beam with bending stiffness periodic in the spatial coordinate. Using a perturbation expansion technique the free vibration solution is obtained in a closed-form, and the effects of system parameters on beam response are explored. It is found that periodic stiffness acts to modulate the modal displacements from the characteristic shape of a simple sine wave. The results are verified by a finite element solution and through experimental testing. Author

N87-22727*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRUCTURAL DYNAMICS SYSTEM MODEL REDUCTION
J. C. CHEN, T. L. ROSE, and B. K. WADA *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 625-668 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

Loads analysis for structural dynamic systems is usually performed by finite element models. Because of the complexity of the structural system, the model contains large number of degree-of-freedom. The large model is necessary since details of the stress, loads and responses due to mission environments are computed. However, a simplified model is needed for other tasks such as pre-test analysis for modal testing, and control-structural interaction studies. A systematic method of model reduction for modal test analysis is presented. Perhaps it will be of some help in developing a simplified model for the control studies. Author

N87-22728*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
WORKSHOP ON STRUCTURAL DYNAMICS AND CONTROL INTERACTION OF FLEXIBLE STRUCTURES
L. P. DAVIS, J. F. WILSON (Sperry Corp., Phoenix, Ariz.), and R. E. JEWELL *In its* Structural Dynamics and Control Interaction of Flexible Structures p 669-690 Apr. 1987 Reprinted from Vibration Damping Workshop, 6 Mar. 1986
Avail: NTIS HC A99/MF E03 CSCL 20K

The Hubble Space Telescope features the most exacting line of sight jitter requirement thus far imposed on a spacecraft pointing system. Consideration of the fine pointing requirements prompted an attempt to isolate the telescope from the low level vibration disturbances generated by the attitude control system reaction wheels. The primary goal was to provide isolation from axial component of wheel disturbance without compromising the control system bandwidth. A passive isolation system employing metal springs in parallel with viscous fluid dampers was designed, fabricated, and space qualified. Stiffness and damping characteristics are deterministic, controlled independently, and were demonstrated to remain constant over at least five orders of input disturbance magnitude. The damping remained purely viscous even at the data collection threshold of .16 x .000001 in input displacement, a level much lower than the anticipated Hubble Space Telescope disturbance amplitude. Vibration attenuation goals were obtained and ground test of the vehicle has demonstrated the isolators are transparent to the attitude control system. Author

N87-22733*# General Electric Co., Philadelphia, Pa. Space Div.
IMPACT OF SPACE STATION APPENDAGE VIBRATIONS ON THE POINTING PERFORMANCE OF GIMBALLED PAYLOADS
ROBERT O. HUGHES *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures 841-866 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

A study of the interface problems between the Space Station Structure (vibrations) and the Payload Pointing Control System was undertaken. A major goal of the study was to identify any bounding factors that might limit the achievement of required pointing accuracies. A major result is that the space station will have a disturbance-rich environment and the background levels will be large enough to impact the pointing of some of the payloads. The need for an interface vibration specification between the structure and the payloads was identified. Author

N87-22738*# Boeing Aerospace Co., Seattle, Wash.
HIGH SPEED SIMULATION OF FLEXIBLE MULTIBODY DYNAMICS
A. D. JACOT, R. E. JONES, and C. D. JUENGST *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 979-998 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 09B

A multiflexible body dynamics code intended for fast turnaround control design trades is described. Nonlinear rigid body dynamics and linearized flexible dynamics combine to provide efficient solution of the equations of motion. Comparison with results from the DISCOS code provide verification of accuracy. Author

N87-22739*# Texas Univ., Austin. Dept. of ASE-EM.
LANCZOS MODES FOR REDUCED-ORDER CONTROL OF FLEXIBLE STRUCTURES
ROY R. CRAIG, JR. and RUSSELL M. TURNER *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 999-1012 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

Lanczos mode models represent low-frequency forced response better than do normal mode models and can be developed for both continuous and finite element structural representations. It was recommended that Lanczos mode models for systems with multiple input and/or rigid body modes should be developed; numerical stability of the Lanczos algorithm should be assessed; and control system designs employing the Lanczos mode models should be attempted. B.G.

N87-22743*# Auburn Univ., Ala. Dept. of Aerospace Engineering.
A NEW APPROACH FOR VIBRATION CONTROL IN LARGE SPACE STRUCTURES
K. KUMAR and J. E. COCHRAN, JR. *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1079-1094 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

An approach for augmenting vibration damping characteristics in space structures with large panels is presented. It is based on generation of bending moments rather than forces. The moments are generated using bimetallic strips, suitably mounted at selected stations on both sides of the large panels, under the influence of differential solar heating, giving rise to thermal gradients and stresses. The collocated angular velocity sensors are utilized in conjunction with mini-servos to regulate the control moments by flipping the bimetallic strips. A simple computation of the rate of dissipation of vibrational energy is undertaken to assess the effectiveness of the proposed approach. Author

N87-22745*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODELING OF CONTROLLED FLEXIBLE STRUCTURES WITH IMPULSIVE LOADS
M. ZAK *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1161-1178 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The characteristic wave approach is developed as an alternative to modal methods which may lead to significant errors in the presence of impulsive or concentrated loads. The method is applied to periodic structures. Some special phenomena like cumulation effects and transitions to ergodicity are analyzed. Author

N87-22747*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON THE CONTROL OF STRUCTURES BY APPLIED THERMAL GRADIENTS
DON EDBERG and JAY-C. CHEN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1214-1250 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

Some preliminary results of research on control of flexible structures performed at the Jet Propulsion Laboratory are presented. It was shown that the thermoelectric device is a feasible actuator and may effectively be used to control structures, provided the structure has a relatively low thermal inertia. The control law only depends on the open-loop system natural frequency. B.G.

N87-22749*# Boeing Aerospace Co., Seattle, Wash.
EXPERIMENTAL CHARACTERIZATION OF DEPLOYABLE TRUSSES AND JOINTS
R. IKEGAMI, S. M. CHURCH, D. A. KEINHOLZ, and B. L. FOWLER (CSA Engineering, Inc., Palo Alto, Calif.) *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1271-1288 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

The structural dynamic properties of trusses are strongly affected by the characteristics of joints connecting the individual beam elements. Joints are particularly significant in that they are often the source of nonlinearities and energy dissipation. While the joints themselves may be physically simple, direct measurement is often necessary to obtain a mathematical description suitable for inclusion in a system model. Force state mapping is a flexible, practical test method for obtaining such a description, particularly when significant nonlinear effects are present. It involves measurement of the relationship, nonlinear or linear, between force transmitted through a joint and the relative displacement and velocity across it. An apparatus and procedure for force state mapping are described. Results are presented from tests of joints used in a lightweight, composite, deployable truss built by the Boeing Aerospace Company. The results from the joint tests are used to develop a model of a full 4-bay truss segment. The truss segment was statically and dynamically tested. The results of the truss tests are presented and compared with the analytical predictions from the model. Author

N87-22750*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SYSTEM IDENTIFICATION FOR LARGE SPACE STRUCTURE DAMAGE ASSESSMENT
J. C. CHEN and J. A. GARBA *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1289-1318 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The need for monitoring the dynamic characteristics of large structural systems for purposes of assessing the potential degradation of structural properties was established. A theory for assessing the occurrence, location, and extent of potential damage was developed utilizing on-orbit response measurements. Feasibility of the method is demonstrated using a simple structural system as an example. Author

N87-22751*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION STRUCTURES AND DYNAMICS TEST PROGRAM
FRANK M. BUGG, E. W. IVEY, C. J. MOORE, and JOHN S. TOWNSEND *In its* Structural Dynamics and Control Interaction of Flexible Structures p 1319-1332 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The design, construction, and operation of a low-Earth orbit space station poses challenges for development and implementation of technology. One specific challenge is the development of a dynamics test program for defining the space station design requirements, and identifying and characterizing phenomena affecting the space station's design and development. The test proposal, as outlined, is a comprehensive structural dynamics program to be launched in support of the space station (SS). Development of a parametric data base and verification of the mathematical models and analytical analysis tools necessary for engineering support of the station's design, construction, and operation provide the impetus for the dynamics test program. The four test phases planned are discussed: testing of SS applicable structural concepts; testing of SS prototypes; testing of actual SS structural hardware; and on-orbit testing of SS construction. B.G.

N87-23682# California Univ., Berkeley. Electronics Research Lab.
AN INTEGRATED, OPTIMIZATION-BASED APPROACH TO THE DESIGN AND CONTROL OF LARGE SPACE STRUCTURES Final Technical Report, 1 Oct. 1983 - 30 Sep. 1986
ELIJAH POLAK, KARL S. PISTER, and ROBERT L. TAYLOR 30 Sep. 1986 10 p
(Contract AF-AFOSR-0361-83)
(AD-A179459; AFOSR-87-0402TR) Avail: NTIS HC A02/MF A01 CSCL 20K

This research was aimed at laying the groundwork for a long term project on the integrated, optimization-based design of large, flexible structures and their control systems. Research was carried out in four areas: (1) modeling the dynamic behavior of simple flexible structures; (2) development of a theory of nondifferentiable optimization algorithms for the solution of problems with max function type inequality constraints; (3) exploration of the use of optimization in optimization-based design of large, flexible structures and their control systems; and (4) interactive software for optimization-based control system design. GRA

N87-23680*# Catholic Univ. of America, Washington, D.C. Dept. of Mechanical Engineering.
MODIFIED INDEPENDENT MODAL SPACE CONTROL METHOD FOR ACTIVE CONTROL OF FLEXIBLE SYSTEMS
A. BAZ and S. POH Jul. 1987 32 p
(Contract NAG5-520; NAG5-749)
(NASA-CR-181065; NAS 1.26:181065) Avail: NTIS HC A03/MF A01 CSCL 13I

A modified independent modal space control (MIMSC) method is developed for designing active vibration control systems for large flexible structures. The method accounts for the interaction between the controlled and residual modes. It incorporates also optimal placement procedures for selecting the optimal locations of the actuators in the structure in order to minimize the structural vibrations as well as the actuation energy. The MIMSC method relies on an important feature which is based on time sharing of a small number of actuators, in the modal space, to control effectively a large number of modes. Numerical examples are presented to illustrate the application of the method to generic flexible systems. The results obtained suggest the potential of the devised method in designing efficient active control systems for large flexible structures. Author

N87-24495*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA/DOD CONTROL/STRUCTURES INTERACTION TECHNOLOGY, 1986
ROBERT L. WRIGHT, comp. Jun. 1987 314 p Conference held in Norfolk, Va., 18-21 Nov. 1986
(NASA-CP-2447-PT-2; L-16242-PT-2; NAS 1.55:2447-PT-2)
Avail: NTIS HC A14/MF A01 CSCL 22B

Papers presented at the CSI Technology Conference are given. The conference was jointly sponsored by the NASA Office of Aeronautics and Space Technology and the Department of Defense. The conference is the beginning of a series of annual conferences whose purpose is to report to industry, academia, and government agencies the current status of Control/Structures Interaction technology. The conference program was divided into five sessions: (1) Future spacecraft requirements; Technology issues and impact; (2) DOD special topics; (3) Large space systems technology; (4) Control of flexible structures, and (5) Selected NASA research in control structures interaction.

N87-24497*# Air Force Weapons Lab., Kirtland AFB, N. Mex.
JOINT OPTICS STRUCTURES EXPERIMENT (JOSE)
DAVID FOUNDS *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 591-602 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 20F

The objectives of the JOSE program is to develop, demonstrate, and evaluate active vibration suppression techniques for Directed Energy Weapons (DEW). DEW system performance is highly influenced by the line-of-sight (LOS) stability and in some cases by the wave front quality. The missions envisioned for DEW systems by the Strategic Defense Initiative require LOS stability and wave front quality to be significantly improved over any current demonstrated capability. The Active Control of Space Structures (ACOSS) program led to the development of a number of promising structural control techniques. DEW structures are vastly more complex than any structures controlled to date. They will be subject to disturbances with significantly higher magnitudes and wider bandwidths, while holding higher tolerances on allowable motions and deformations. Meeting the performance requirements of the JOSE program requires upgrading the ACOSS techniques to meet new more stringent requirements, the development of requisite sensors and acturators, improved control processors, highly accurate system identification methods, and the integration of hardware and methodologies into a successful demonstration.
Author

N87-24501*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN, CONSTRUCTION, AND UTILIZATION OF A SPACE STATION ASSEMBLED FROM 5-METER ERECTABLE STRUTS
MARTIN M. MIKULAS, JR. and HAROLD G. BUSH *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 675-699 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The primary characteristics of the 5-meter erectable truss is presented, which was baselined for the Space Station. The relatively large 5-meter truss dimension was chosen to provide a deep beam for high bending stiffness yet provide convenient mounting locations for space shuttle cargo bay size payloads which are approx. 14.5 ft (4.4 m) in diameter. Truss nodes and quick attachment erectable joints are described which provide for evolutionary three dimensional growth and for simple maintenance and repair. A mobile remote manipulator system is described which is provided to assist in station construction and maintenance. A discussion is also presented of the construction of the Space Station and the associated extravehicular active (EVA) time.
Author

N87-24505*# TRW Space Technology Labs., Redondo Beach, Calif.
APPLICATION OF PHYSICAL PARAMETER IDENTIFICATION TO FINITE-ELEMENT MODELS
ALLEN J. BRONOWICKI, MICHAEL S. LUKICH, and STEVEN P. KURITZ *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 747-755 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The time domain parameter identification method described previously is applied to TRW's Large Space Structure Truss Experiment. Only control sensors and actuators are employed in the test procedure. The fit of the linear structural model to the test data is improved by more than an order of magnitude using a physically reasonable parameter set. The electro-magnetic control actuators are found to contribute significant damping due to a combination of eddy current and back electro-motive force (EMF) effects. Uncertainties in both estimated physical parameters and modal behavior variables are given. Author

N87-24510*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GROUND TEST OF LARGE FLEXIBLE STRUCTURES
BEN K. WADA *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 831-850 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

Many future mission models require large space (LSS) which have accurate surfaces and/or the capability of being accurately aligned. If ground test approaches which will provide adequate confidence of the structrual performance to the program managers are not developed, many viable structural concepts may never be utilized. The size and flexibility of many of the structural concepts will preclude the use of the current ground test methods because of the adverse effects of the terrestrial environment. The challenge is to develop new test approaches which will provide confidence in the capability of LSS to meet performance requirements prior to flight. The activities on ground testing of LSS are described. Since some of the proposed structural systems cannot be tested in entirety, a coordinated ground test analytical model program is required to predict structural performance in space. Several concepts of ground testing under development are addressed.
Author

N87-24516# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
INVESTIGATION FOR DAMPING DESIGN AND RELATED NONLINEAR VIBRATIONS OF SPACECRAFT STRUCTURES Final Report
E. HILBRANDT, I. KOLSCH, and W. CHARON Paris, France ESA Dec. 1985 438 p
(Contract ESTEC-5326/83-NL-PB(SC))
(EMSB-64/85; ESA-CR(P)-2329; ETN-87-99881) Avail: NTIS HC A19/MF A01

The sources of damping in spacecraft structures and substructures, their representation, analytical methods, and test procedures are investigated. Design concepts are developed and are verified on hardware applications. The description of the single damping sources is one of the main problems for the damping prediction method for substructures. The efficiency of the different damping sources differs by orders of magnitude. Damping prediction of substructures by the loss factor analysis method is sensitive to damping source characterization. The damping prediction of the substructures program developed, is written as a data base oriented batch program. A finite element calculation delivers all modal data for the total description of the structure including eigenvalues, eigenmodes, modal stresses, modal strains, and energies on element level.
ESA

N87-24517# Systems Engineering Labs., Inc., Greenbelt, Md.
SPECTRAL FACTORIZATION AND HOMOGENIZATION METHODS FOR MODELING AND CONTROL OF FLEXIBLE STRUCTURES Final Report, Sep. 1984 - Sep. 1986
WILLIAM H. BENNETT, G. L. BLANKENSHIP, and H. G. KWATNY 15 Dec. 1986 188 p
(Contract F49620-84-C-0115)
(AD-A179726; SEI-TR-86-14; AFOSR-87-0502TR) Avail: NTIS HC A09/MF A01 CSCL 22B

This report describes continuum modeling and vibration control of flexible structures with application to active control of vibrations in large space structures. A comprehensive methodology is discussed for the construction of effective (linear) models for large composite structures consisting of various flexible members(e.g. beams, trusses, etc.) and rigid body elements. It is convenient to concentrate on frequency domain modeling. A systematic procedure is shown for computing the irrational transfer functions. Then by standard transform methods a complete hybrid model is developed. The methods were coded in a computer algebra system (SMP was used) which automated the model building process and produced Fortran code for numerical evaluation of the frequency responses. Effective continuum models of lattice structures with regular infrastructure can be obtained by a systematic procedure based on an asymptotic analysis of multiple scales called homogenization. This method is applied to several examples and accurate computation made of the required parameters of such continuum models somewhat more subtle than merely averaging over lattice cells. For the computation of distributed parameter control an optimal frequency domain method is based on solving an associated Wiener Hopf problem. The method employs effective numerical algorithms (e.g. FFT, etc.) to computn a certain spectral factorization of a possibly matrix valued (in the multiple control case) Hermittian, positive definite transform by sampling the frequency response. The control laws take the form of distributed state feedback with respect to a naturally defined, distributed state-space of functions over the spatial domain of the structure.
GRA

N87-24520*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE STRUCTURES TESTING
HENRY WAITES and H. EUGENE WORLEY Jun. 1987 22 p
(NASA-TM-100306; NAS 1.15:100306) Avail: NTIS HC A02/MF A01 CSCL 22B

There is considerable interest in the development of testing concepts and facilities that accurately simulate the pathologies believed to exist in future spacecraft. Both the Government and Industry have participated in the development of facilites over the past several years. The progress and problems associated with the development of the Large Space Structure Test Facility at the Marshall Flight Center are presented. This facility was in existence for a number of years and its utilization has run the gamut from total in-house involvement, third party contractor testing, to the mutual participation of other Government Agencies in joint endeavors.
Author

N87-25349*# Astro Aerospace Corp., Carpinteria, Calif.
DESIGN, DEVELOPMENT AND FABRICATION OF A DEPLOYABLE/RETRACTABLE TRUSS BEAM MODEL FOR LARGE SPACE STRUCTURES APPLICATION Final Report
LOUIS R. ADAMS Jun. 1987 64 p
(Contract NAS1-18013)
(NASA-CR-178287; NAS 1.26:178287; AAC-TN-1150-REV-A)
Avail: NTIS HC A04/MF A01 CSCL 22B

The design requirements for a truss beam model are reviewed. The concept behind the beam is described. Pertinent analysis and studies concerning beam definition, deployment loading, joint compliance, etc. are given. Design, fabrication and assembly procedures are discussed.
Author

N87-25357# British Columbia Univ., Vancouver. Dept. of Mechanical Engineering.
A FORMULATION FOR STUDYING STEADY STATE/TRANSIENT DYNAMICS OF A LARGE CLASS OF SPACECRAFT AND ITS APPLICATION
A. M. IBRAHIM and V. J. MODI *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics p 25-30 Dec. 1986
(Contract NSERC-G-1547)
Avail: NTIS HC A22/MF A01

A formulation for studying dynamics of a system, consisting of n connected flexible deployable members forming a topological tree or a closed configuration, is presented. The mathematical description of the system can be a combination of discrete and distributed coordinates. Joints, elastic and dissipative, permit relative rotation and translation between bodies. The elastic deformations can be discretized using admissible functions, finite elements, or lumped mass method. Rotations of the members, as well as of the entire system, can be described using a set of orientation angles, Euler parameters or Rodrigues vectors. The formulation accounts for: the presence of momentum or reaction wheels; thrusters distributed over the flexible and rigid portions; and any prescribed forms of energy dissipation mechanisms. The formulation is valid for orbiting as well as ground based and marine systems. Application of the formulation is illustrated through an example in spacecraft dynamics.
ESA

N87-25359# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
THE EFFECTS OF STRUCTURAL PERTURBATIONS ON DECOUPLED CONTROL
R. A. CALICO and R. L. HINRICHSEN *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics

p 39-45 Dec. 1986
Avail: NTIS HC A22/MF A01

The effects of structural perturbations on the decoupled control of a large space structure are considered. The structure is controlled through multiple subcontrollers, each of which controls a subset of the spacecraft modes. The stability of the entire system is assured by constraining the gain matrices for the individual subcontrollers such that the stability of the system is not affected by the coupling between the subcontrollers. Structural perturbations reintroduce coupling among the subcontrollers, which may lead to instability. This coupling is shown to be related to changes in the row and column spaces of the individual control and observation matrices, respectively. A simple test for the determination of the effects of these changes is presented. The use of the test is evaluated on the control of the CSDL I spacecraft using three subcontrollers. ESA

N87-25492* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DEPLOYABLE GEODESIC TRUSS STRUCTURE Patent

MARTIN M. MIKULAS, JR., inventor (to NASA), MARVIN D. RHODES, inventor (to NASA), and J. WAYNE SIMONTON, inventor (to NASA) 7 Jul. 1987 9 p Filed 20 Feb. 1986 Supersedes N86-24867 (24 - 15, p 2443)
(NASA-CASE-LAR-13113-1; US-PATENT-4,677,803; US-PATENT-APPL-SN-831371; US-PATENT-CLASS-52-646; US-PATENT-CLASS-52-108; US-PATENT-CLASS-52-632; US-PATENT-CLASS-182-152) Avail: US Patent and Trademark Office CSCL 13I

A deployable geodesic truss structure which can be deployed from a stowed state to an erected state is described. The truss structure includes a series of bays, each bay having sets of battens connected by longitudinal cross members which give the bay its axial and torsional stiffness. The cross members are hinged at their mid point by a joint so that the cross members are foldable for deployment or collapsing. The bays are deployed and stabilized by actuator means connected between the mid point joints of the cross members. Hinged longerons may be provided to also connect the sets of battens and to collapse for stowing with the rest of the truss structure.
Official Gazette of the U.S. Patent and Trademark Office

N87-25576*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

COLLECT LOCK JOINT FOR SPACE STATION TRUSS Patent Application

CLARENCE J. WESSELSKI, inventor (to NASA) 1 Apr. 1987 19 p
(NASA-CASE-MSC-21207-1; US-PATENT-APPL-SN-032818)
Avail: NTIS HC A02/MF A01 CSCL 13K

A lock joint for a space station has a plurality of struts joined together in a predetermined configuration by node point fittings. The fittings have removable inserts therein. The lock joint has an elongated housing connected at one end to a strut. A split-fingered collet is mounted within the housing for movement reciprocally therein. A handle on the housing is connected to the collet for moving the collet into the insert where the fingers of the collet expand to lock the joint to the fitting. NASA

N87-25605*# Catholic Univ. of America, Washington, D.C. Dept. of Mechanical Engineering.

A COMPARISON BETWEEN IMSC, PI AND MIMSC METHODS IN CONTROLLING THE VIBRATION OF FLEXIBLE SYSTEMS

A. BAZ and S. POH Aug. 1987 31 p
(Contract NAG5-520; NAG5-749)
(NASA-CR-181156; NAS 1.26:181156) Avail: NTIS HC A03/MF A01 CSCL 20K

A comparative study is presented between three active control algorithms which have proven to be successful in controlling the vibrations of large flexible systems. These algorithms are: the Independent Modal Space Control (IMSC), the Pseudo-inverse (PI), and the Modified Independent Modal Space Control (MIMSC). Emphasis is placed on demonstrating the effectiveness of the MIMSC method in controlling the vibration of large systems with small number of actuators by using an efficient time sharing strategy. Such a strategy favors the MIMSC over the IMSC method, which requires a large number of actuators to control equal number of modes, and also over the PI method which attempts to control large number of modes with smaller number of actuators through the use of an in-exact statistical realization of a modal controller. Numerical examples are presented to illustrate the main features of the three algorithms and the merits of the MIMSC method.
Author

N87-25606*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

PRELIMINARY DESIGN, ANALYSIS, AND COSTING OF A DYNAMIC SCALE MODEL OF THE NASA SPACE STATION Final Report

M. J. GRONET, E. D. PINSON, H. L. VOQUI, E. F. CRAWLEY, and M. R. EVERMAN (AEC-ABLE Engineering Co., Inc., Goleta, Calif.) Washington NASA Jul. 1987 208 p
(Contract NAS1-18229)
(NASA-CR-4068; NAS 1.26:4068; LMSC-F177633) Avail: NTIS HC A10/MF A01 CSCL 20K

The difficulty of testing the next generation of large flexible space structures on the ground places an emphasis on other means for validating predicted on-orbit dynamic behavior. Scale model technology represents one way of verifying analytical predictions with ground test data. This study investigates the preliminary design, scaling and cost trades for a Space Station dynamic scale model. The scaling of nonlinear joint behavior is studied from theoretical and practical points of view. Suspension system interaction trades are conducted for the ISS Dual Keel Configuration and Build-Up Stages suspended in the proposed NASA/LaRC Large Spacecraft Laboratory. Key issues addressed are scaling laws, replication vs. simulation of components, manufacturing, suspension interactions, joint behavior, damping, articulation capability, and cost. These issues are the subject of parametric trades versus the scale model factor. The results of these detailed analyses are used to recommend scale factors for four different scale model options, each with varying degrees of replication. Potential problems in constructing and testing the scale model are identified, and recommendations for further study are outlined. Author

N87-26071*# Carnegie-Mellon Univ., Pittsburgh, Pa.

RESPONSE OF JOINT DOMINATED SPACE STRUCTURES Semiannual Report

May 1987 73 p
(Contract NAG1-612)
(NASA-CR-180564; NAS 1.26:180564) Avail: NTIS HC A04/MF A01 CSCL 22B

An approximate method is developed for estimating the transient response of nonlinear systems in terms of linearized modes of response. Its advantages are that it is computationally more efficient than the time integration method and that it is possible to view the design problem in the more traditional physical terms of modal response. The major drawback of the approximate method is loss of accuracy. It seems that both approximate methods and time integration have their roles in design. Approximate methods provide efficient tools for performing parametric studies and they supply physical insights into how to optimize system performance that are not easily inferred from strictly numerical methods. Time integration provides a method for assessing the accuracy of the approximate solution for key simulations and for fine tuning the final design. In the procedure presented the nonlinear system is approximated by an equivalent linear system in which the system parameters are constant over the range of transient response.
Author

N87-26075# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).

DEVELOPMENT OF EXPERIMENTAL/ANALYTICAL CONCEPTS FOR STRUCTURAL DESIGN VERIFICATION Final Report

E. HORNUNG, K. ECKHARDT, E. ERBEN, E. HUENERS, N. NIEDBAL, H. OERY, and H. GLASER Paris, France ESA Feb. 1985 139 p
(Contract ESTEC-5166/82-NL-PB(SC))
(ESA-CR(P)-2340; ETN-87-99991) Avail: NTIS HC A06/MF A01

Spacecraft structure analytical and test verification methods were reviewed. It is concluded that in general adequate verification capabilities exist to provide the required level of confidence in spacecraft projects. When optimal verification procedures are performed in a project low safety margins might be sufficient for the realization of the project. However, the employment of minimum safety margins, i.e., margins as requested by the launcher authorities, is not encountered in practice in the space industry because of user uncertainty as to launcher loads. To improve spacecraft design and verification activities better knowledge is required for launcher loads as they arise in reality. The recording of flight responses and loads during launch is essential for an overall improvement of design and verification activities. Such activities allow the employment of representative safety margins, and eliminate excessive margins currently employed to cover load uncertainties. ESA

N87-26065*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL EVALUATION OF SMALL-SCALE ERECTABLE TRUSS HARDWARE
DAVID M. MCGOWAN and MARK S. LAKE Jun. 1987 15 p
(NASA-TM-89068; NAS 1.15:89068) Avail: NTIS HC A02/MF A01 CSCL 22B

To aid in the prediction of the dynamic behavior of the space station, a one-tenth scale dynamic test model is to be constructed of commercially available, small scale truss hardware. Tests have been performed to determine the axial stiffness characteristics and failure loads of the truss joint. A parametric study has shown that the stiffness of the joint increases as the attachment bolt torque value is increased. Furthermore, at torque values equal to or higher than 250 in-lbs, hysteresis in the load-deflection curve is essentially eliminated. Also, the joint stiffness remained relatively constant between specimens. The effective stiffness of a joint subassembly tested is 76 percent that of the strut. Tensile and compressive failure occurred in the region of the bonded plug, with lower failure loads corresponding to compressive loadings. Author

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N87-26365*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronatuics and Astronautics.
JOINT NONLINEARITY EFFECTS IN THE DESIGN OF A FLEXIBLE TRUSS STRUCTURE CONTROL SYSTEM
MATHIEU MERCADAL Dec. 1986 164 p
(Contract NAG1-126)
(NASA-CR-180633; NAS 1.26:180633; SSL-22-86) Avail: NTIS HC A08/MF A01 CSCL 20K

Nonlinear effects are introduced in the dynamics of large space truss structures by the connecting joints which are designed with rather important tolerances to facilitate the assembly of the structures in space. The purpose was to develop means to investigate the nonlinear dynamics of the structures, particularly the limit cycles that might occur when active control is applied to the structures. An analytical method was sought and derived to predict the occurrence of limit cycles and to determine their stability. This method is mainly based on the quasi-linearization of every joint using describing functions. This approach was proven successful when simple dynamical systems were tested. Its applicability to larger systems depends on the amount of computations it requires, and estimates of the computational task tend to indicate that the number of individual sources of nonlinearity should be limited. Alternate analytical approaches, which do not account for every single nonlinearity, or the simulation of a simplified model of the dynamical system should, therefore, be investigated to determine a more effective way to predict limit cycles in large dynamical systems with an important number of distributed nonlinearities. Author

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N87-26370*# Iowa Univ., Iowa City. Dept. of Mechanical Engineering.
SHAPE DESIGN SENSITIVITY ANALYSIS AND OPTIMAL DESIGN OF STRUCTURAL SYSTEMS
KYUNG K. CHOI 1987 54 p
(Contract NAG1-215)
(NASA-CR-181095; NAS 1.26:181095) Avail: NTIS HC A04/MF A01 CSCL 20K

The material derivative concept of continuum mechanics and an adjoint variable method of design sensitivity analysis are used to relate variations in structural shape to measures of structural performance. A domain method of shape design sensitivity analysis is used to best utilize the basic character of the finite element method that gives accurate information not on the boundary but in the domain. Implementation of shape design sensitivty analysis using finite element computer codes is discussed. Recent numerical results are used to demonstrate the accuracy obtainable using the method. Result of design sensitivity analysis is used to carry out design optimization of a built-up structure. Author

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N87-26387 Georgia Inst. of Tech., Atlanta.
VIBRATION CONTROL OF FLEXIBLE STRUCTURES USING PIEZOELECTRIC DEVICES AS SENSORS AND ACTUATORS
Ph.D. Thesis
MICHAEL WALTER OBAL 1986 266 p
Avail: Univ. Microfilms Order No. DA8707860

The problem of the active control of linear elastic structures using piezoceramic transducers as sensors and actuators was investigated by a combined theoretical and experimental approach. The optimal rate feedback gain distribution of an active structure with multiple collocated sensors and actuators was obtained by using a limited state feedback approach which resulted in an increase in system damping. To model the active structure for the optimal control problem, a finite element model was developed. An active element consisting of a simple beam element with a bonded unimorphic piezoceramic sensors and actuators was obtained. The model incorporates the electromechanical coupling of the transducers, bonding effects and a mathematical model for the feedback signal conditioning circuitry. The resulting discrete degrees of freedom model is in the form of a set of coupled ordinary differential equations which describe the dynamic behavior of the active structure. To obtain the unknown dynamic coupling coefficients that represent the effects of bonding and other parameters of the model accurately, parameter identification methods were used. Modal control was also experimentally demonstrated. Dissert. Abstr.

N87-26397*# Carnegie Inst. of Tech., Pittsburgh, Pa.
RESPONSE OF JOINT DOMINATED SPACE STRUCTURES
Final Report
Aug. 1987 84 p
(Contract NAG1-612)
(NASA-CR-181202; NAS 1.26:181202) Avail: NTIS HC A05/MF A01 CSCL 20K

An efficient linearization method is presented for calculating the transient response of nonlinear systems due to initial disturbances. The method is an extension of the describing function approach in which the steady state response of the system is calculated by representing the nonlinear element, typically joints in the case of space structures, by impedances which are functions of the amplitude of response. Thus, the problem of solving the differential equation for the steady state response becomes one of solving a set of nonlinear algebraic equations involving the steady state amplitudes and phases of the system. It is shown that for the transient case the steady state impedances can be averaged over the range of responses in order to provide equivalent values of stiffness and damping that, for a given set of initial displacements, may be treated as being constant for purposes of calculating system response. Single degree of freedom system are used to demonstrate the method and to develop an approach for optimizing the joint's characteristics so as to minimize transient response times. The use of this method for response estimation and optimization in multiple degree of freedom systems is investigated. Author

N87-26583*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
PROJECTION FILTERS FOR MODAL PARAMETER ESTIMATE FOR FLEXIBLE STRUCTURES Progress Report, period ending 31 Dec. 1986
JEN-KUANG HUANG and CHUNG-WEN CHEN Feb. 1987 30 p
(Contract NAG1-655)
(NASA-CR-180303; NAS 1.26:180303) Avail: NTIS HC A03/MF A01 CSCL 12A

Single-mode projection filters are developed for eigensystem parameter estimates from both analytical results and test data. Explicit formulations of these projection filters are derived using the pseudoinverse matrices of the controllability and observability matrices in general use. A global minimum optimization algorithm is developed to update the filter parameters by using interval analysis method. Modal parameters can be attracted and updated in the global sense within a specific region by passing the experimental data through the projection filters. For illustration of this method, a numerical example is shown by using a one-dimensional global optimization algorithm to estimate model frequencies and dampings. Author

N87-26921 Virginia Polytechnic Inst. and State Univ., Blacksburg.
AN INVESTIGATION OF METHODOLOGY FOR THE CONTROL AND FAILURE IDENTIFICATION OF FLEXIBLE STRUCTURES Ph.D. Thesis
ZEEN CHUL KIM 1986 129 p
Avail: Univ. Microfilms Order No. DA8704683

The characteristics of four methods is examined for the control of flexible structures and the control performances of each method. Various control performance measures, such as control gain magnitude, settling time and overshoot in transient response, actuator phase and gain margins, and stability in the presence of actuator failure are emphasized. In conjunction with the system performance, a systematic approach to the choice of weighting matrices for optimal control is presented. The approach shows a relation between the weighting matrices and the closed loop eigenvalues. The robustness of Independent Modal Space Control (IMSC) is examined. In general, the parameters of the control system are usually approximated, so that the designed controller, based on a postulated model, will not perform on the actual system as expected. It is shown that when the IMSC method is used with collocated sensors and actuators, the modelling errors in the postulated system cannot lead to instability of the closed loop system containing control modes and residual modes. However, in the case of coupled control (MGPP), this property cannot be shown. This points to the robustness of the IMSC method with respect to the modelling errors. Author

N87-27259# Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE EFFECT OF NONLINEARITIES ON FLEXIBLE STRUCTURES Annual Report, 30 Apr. 1986 - 30 Apr. 1987
A. H. NAYFEH and D. T. MOOK 30 Apr. 1987 9 p
(Contract AF-AFOSR-0090-86)
(AD-A181735; AFOSR-87-0712TR) Avail: NTIS HC A02/MF A01 CSCL 20K

Experimental-theoretical studies have been conducted on the influence of nonlinearities on flexible structures in the presence of either an external or a parametric excitation. A single-degree-of-freedom system with quadratic and cubic nonlinearities under the influence of a harmonic parametric excitation was studied using the method of multiple scales and digital-and analog-computer simulations. A global bifurcation diagram was obtained showing the different possible attractors (point, limit cycle, chaotic attractors). For small excitation amplitudes, the perturbation results are in excellent agreement with the digital- and analog-computer simulations. For moderate to large excitation amplitudes, the accuracy of the perturbation solution is questionable and only digital- and analog-computer simulations were used. The results are in full agreement. GRA

N87-27260*# Old Dominion Univ., Norfolk, Va. Dept. of Civil Engineering.
SUBSTRUCTURE ANALYSIS USING NICE/SPAR AND APPLICATIONS OF FORCE TO LINEAR AND NONLINEAR STRUCTURES Progress Report, period ending 30 Jun. 1987
ZIA RAZZAQ, VENKATESH PRASAD, SIVA PRASAD DARBHAMULLA, RAVINDER BHATI, and CAI LIN Aug. 1987 129 p
(Contract NAG1-438)
(NASA-CR-180317; NAS 1.26:180317) Avail: NTIS HC A07/MF A01 CSCL 20K

Parallel computing studies are presented for a variety of structural analysis problems. Included are the substructure planar analysis of rectangular panels with and without a hole, the static analysis of space mast, using NICE/SPAR and FORCE, and substructure analysis of plane rigid-jointed frames using FORCE. The computations are carried out on the Flex/32 MultiComputer using one to eighteen processors. The NICE/SPAR runstream samples are documented for the panel problem. For the substructure analysis of plane frames, a computer program is developed to demonstrate the effectiveness of a substructuring technique when FORCE is enforced. Ongoing research activities for an elasto-plastic stability analysis problem using FORCE, and stability analysis of the focus problem using NICE/SPAR are briefly summarized. Speedup curves for the panel, the mast, and the frame problems provide a basic understanding of the effectiveness of parallel computing procedures utilized or developed, within the domain of the parameters considered. Although the speedup curves obtained exhibit various levels of computational efficiency, they clearly demonstrate the excellent promise which parallel computing holds for the structural analysis problem. Source code is given for the elasto-plastic stability problem and the FORCE program. Author

N87-27705# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
MAXIMUM LIKELIHOOD PARAMETER IDENTIFICATION OF FLEXIBLE SPACECRAFT Ph.D. Thesis
QI PING CHU 1987 272 p Sponsored by the Chinese Academy of Sciences, and Technische Hogeschool, Delft, The Netherlands
(ETN-87-90235) Avail: NTIS HC A12/MF A01

The finite element method is applied to generate a linear mathematical model of a general flexible spacecraft in arbitrary orbits. Model order is reduced by a quasi-static approximation of the higher frequency characteristic modes. Stochastic models to approximate modeling errors are proposed. The models for parameter estimation are linear dynamical systems with unknown process noise. Algorithms for maximum likelihood parameter estimation which account for correlations between process and measurement noise are developed. Simulated measurements are used to verify the applicability of the maximum likelihood parameter estimation algorithms to the identification of flexible spacecraft. It is demonstrated that for the spacecraft used, all unknown parameters can be estimated from the simulated measurements simultaneously with the time histories of the system model states. ESA

N87-27713* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELOADED SPACE STRUCTURAL COUPLING JOINTS Patent
MARVIN D. RHODES, inventor (to NASA) 4 Aug. 1987 10 p
Filed 30 Jul. 1986 Supersedes N86-21630 (24 - 23, p 3565
(NASA-CASE-LAR-13489-1; US-PATENT-4,684,156;
US-PATENT-APPL-SN-890445; US-PATENT-CLASS-285-27;
US-PATENT-CLASS-285-31; US-PATENT-CLASS-285-86;
US-PATENT-CLASS-285-373; US-PATENT-CLASS-285-421;

US-PATENT-CLASS-403-341) Avail: US Patent and Trademark Office CSCL 22B

A coupling device for tubular members of large truss structures with a locking collar being the only moving part is described. Each tubular member is constructed with an end bell section that has a belled flange with a mating face, and a necked area which is smaller in diameter than the tubular members to be joined. A split ring is affixed to each tubular member and is constructed so that when two tubular members are laterally moved into axial alignment and the collar is rotated over it, the split ring loads the joint with axial forces by pressing the belled flange mating surfaces together, and a preloading force is provided by the collar mating with a taper on the outside of the split rings. All free play is thereby removed by preloaded force. A major object is to provide an ability to remove and replace individual tubular members without disturbing other structural parts of a truss structure. An additional anticipated use of this joint is to couple high pressure fluid lines.

Official Gazette of the U.S. Patent and Trademark Office

N87-28581*# Boeing Aerospace Co., Seattle, Wash.

SPACE STATION INTEGRATED WALL DESIGN AND PENETRATION DAMAGE CONTROL Final Report

A. R. CORONADO, M. N. GIBBINS, M. A. WRIGHT, and P. H. STERN Jul. 1987 257 p
(Contract NAS8-36426)
(NASA-CR-179165; NAS 1.26:179165; D180-30550-1) Avail: NTIS HC A12/MF A01 CSCL 22B

A methodology was developed to allow a designer to optimize the pressure wall, insulation, and meteoroid/debris shield system of a manned spacecraft for a given spacecraft configuration and threat environment. The threat environment consists of meteoroids and orbital debris, as specified for an arbitrary orbit and expected lifetime. An overall probability of no penetration is calculated, as well as contours of equal threat that take into account spacecraft geometry and orientation. Techniques, tools, and procedures for repairing an impacted and penetrated pressure wall were developed and tested. These techniques are applied from the spacecraft interior and account for the possibility of performing the repair in a vacuum. Hypervelocity impact testing was conducted to: (1) develop and refine appropriate penetration functions, and (2) determine the internal effects of a penetration on personnel and equipment.

Author

N87-28582*# Boeing Aerospace Co., Seattle, Wash.

SPACE STATION INTEGRATED WALL DESIGN AND PENETRATION DAMAGE CONTROL. TASK 3: THEORETICAL ANALYSIS OF PENETRATION MECHANICS Final Report

M. D. BJORKMAN, J. D. GEIGER, and E. E. WILHELM Jul. 1987 150 p
(Contract NAS8-36426)
(NASA-CR-179166; NAS 1.26:179166; D180-30550-2) Avail: NTIS HC A07/MF A01 CSCL 22B

The efforts to provide a penetration code called PEN4 version 10 is documented for calculation of projectile and target states for the impact of 2024-T3 aluminum, R sub B 90 1018 steel projectiles and icy meteoroids onto 2024-T3 aluminum plates at impact velocities from 0 to 16 km/s. PEN4 determines whether a plate is perforated by calculating the state of fragmentation of projectile and first plate. Depth of penetration into the second to n sup th plate by fragments resulting from first plate perforation is determined by multiple cratering. The results from applications are given.

Author

N87-28937 California Inst. of Tech., Pasadena.

AN EXPERIMENTAL INVESTIGATION OF VIBRATION SUPPRESSION IN LARGE SPACE STRUCTURES USING POSITIVE POSITION FEEDBACK Ph.D. Thesis

JAMES L. FANSON 1987 204 p
Avail: Univ. Microfilms Order No. DA8710938

A new technique for vibration suppression in Large Space Structures is demonstrated in laboratory experiments on a thin cantilever beam, resulting in substantially reduced dynamic response. This technique, called Positive Position Feedback (PPF), makes use of generalized displacement measurements to accomplish vibration suppression. The concept of a piezoelectric active-member is developed in relation to controlling space-truss type structures. The active-member functions dually as a structural member and a control actuator. Piezoelectric ceramic material is adhered to a thin cantilever beam and simulates the use of an active-member. This space-realizable control scheme makes use of strain measurements, a preferred measurement quantity for vibration suppression, and internal control forces which completely decouple the rigid-body motion from the elastic motion. A simple necessary and sufficient condition for stability with PPF is presented. This condition is nondynamic and is in general easily satisfied. As a result, PPF is demonstrated to have superior robust stability properties. It is also demonstrated that with PPF, all control and observation spillover is stabilizing. Five experiments are described.

Dissert. Abstr.

N87-29012# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

THE EXTENDABLE AND RETRACTABLE MAST AS SUPPORTING TOOL FOR RIGID SOLAR ARRAYS

M. SCHMID *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 377-383 Nov. 1986
Avail: NTIS HC A21/MF A01

The Extendable and Retractable Mast (ERM) was developed to deploy and retract large foldable structures like solar arrays. By adequate choice of the interfaces between solar array and ERM it is possible to deploy, position, and retract large rollable or foldable, rigid, or flexible solar arrays up to the 40 m deployment range. Since for the attachment of rollable and foldable solar arrays only a tip and base interface on the ERM is necessary, different configurations providing intermediate attachment points along the mast were investigated to deploy and retract rigid solar array panels also.

ESA

N87-29576* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TECHNOLOGY FOR LARGE SPACE SYSTEMS. A BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 17)

Oct. 1987 140 p
(NASA-SP-7046(17); NAS 1.21:7046(17)) Avail: NTIS HC A07 CSCL 22B

This bibliography lists 512 reports, articles, and other documents introduced into the NASA scientific and technical information system between January 1, 1987 and June 30, 1987. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems.

Author

N87-29590*# Columbia Univ., New York, N.Y. Dept. of Civil Engineering and Engineering Mechanics.

VIBRATIONS AND STRUCTUREBORNE NOISE IN SPACE STATION Final Report

R. VAICAITIS, C. S. LYRINTZIS, and D. A. BOFILIOS 9 Oct. 1987 152 p
(Contract NAG1-541)
(NASA-CR-181381; NAS 1.26:181381) Avail: NTIS HC A08/MF A01 CSCL 22B

Analytical models were developed to predict vibrations and structureborne noise generation of cylindrical and rectangular acoustic enclosures. These models are then used to determine structural vibration levels and interior noise to random point input forces. The guidelines developed could provide preliminary information on acoustical and vibrational environments in space station habitability modules under orbital operations. The structural models include single wall monocoque shell, double wall shell, stiffened orthotropic shell, descretely stiffened flat panels, and a coupled system composed of a cantilever beam structure and a stiffened sidewall. Aluminum and fiber reinforced composite materials are considered for single and double wall shells. The end caps of the cylindrical enclosures are modeled either as single or double wall circular plates. Sound generation in the interior space is calculated by coupling the structural vibrations to the acoustic field in the enclosure. Modal methods and transfer matrix techniques are used to obtain structural vibrations. Parametric studies are performed to determine the sensitivity of interior noise environment to changes in input, geometric and structural conditions. Author

N87-29959*# AEC-Able Engineering Co., Inc., Goleta, Calif.
FOLDING, ARTICULATED, SQUARE TRUSS
ROBERT M. WARDEN *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 1-17 May 1987
Avail: NTIS HC A16/MF A01 CSCL 13I

A larger, stronger deployable boom was developed to handle the requirements of larger, heavier payloads in space. The main components of the boom and its deployer are described and their functions explained. Desirable features of the boom are identified and physical properties are reported. Author

N87-29960*# Toshiba Corp., Kanagawa (Japan). Research and Development Center.
THE DESIGN AND DEVELOPMENT OF A TWO-DIMENSIONAL ADAPTIVE TRUSS STRUCTURE
FUMIHIRO KUWAO, SHOICHI MOTOHASHI, MAKOTO YOSHIHARA, KENICHI TAKAHARA, and MICHIHIRO NATORI (Tokyo Univ., Japan) *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 19-34 May 1987
Avail: NTIS HC A16/MF A01 CSCL 13I

The functional model of a two dimensional adaptive truss structure which can purposefully change its geometrical configuration is introduced. The details of design and fabrication such as kinematic analysis, dynamic characteristics analysis and some test results are presented for the demonstration of this two dimensional truss concept. Author

N87-29964*# RCA Aerospace and Defense, East Windsor, N.J. Astro-Space Div.
DEVELOPMENT OF A STANDARD CONNECTOR FOR ORBITAL REPLACEMENT UNITS FOR SERVICEABLE SPACECRAFT
ELLEN F. HEATH, MATTHEW A. BRACCIO, STEVEN D. RAYMUS, and DAVID W. GROSS *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 81-92 May 1987
Avail: NTIS HC A16/MF A01 CSCL 22B

The current trend for spacecraft to be serviceable and repairable in orbit has led to a modular approach to satellite subsystem design. Spacecraft equipment, such as sensors, tape recorders, computers, transponders, batteries, etc., housed in discrete modular units, (Orbital Replacement Units(ORUs)) can be attached and detached to the spacecraft as needed. The interface between the ORU and the spacecraft is crucial. The projected use of robotics and the need for a common mechanism capable of performing several functions puts many constraints on the design of the interface. Such an interface mechanisms was designed and developed called the Standard Interface Connector (SIC) that mates the ORU to the spacecraft. The SIC also provides for the flow of fluids, data, and power between the module and spacecraft. The baseline design presented can be configured to provide various attachment schemes. Tests on SIC models have demonstrated the functionality of the design and its compatibility with current robotics. Author

N87-29966*# Catholic Univ. of America, Washington, D.C. Dept. of Mechanical Engineering.
OPTIMUM SHAPE CONTROL OF FLEXIBLE BEAMS BY PIEZO-ELECTRIC ACTUATORS
A. BAZ and S. POH 1987 35 p
(Contract NAG5-520; NAG5-749)
(NASA-CR-181413; NAS 1.26:181413) Avail: NTIS HC A03/MF A01 CSCL 20K

The utilization of piezoelectric actuators in controlling the static deformation and shape of flexible beams is examined. An optimum design procedure is presented to enable the selection of the optimal location, thickness and excitation voltage of the piezoelectric actuators in a way that would minimize the deflection of the beam to which these actustors are bonded. Numerical examples are presented to illustrate the application of the developed optimization procedure in minimizing structural deformation of beams using ceramic and polymeric piezoelectric actuators bonded to the beams with a typical bonding agent. The obtained results emphasize the importance of the devised rational produce in designing beam-actuator systems with minimal elastic distortions. Author

N87-29999*# George Washington Univ., Washington, D.C. Joint Inst. for Advancement of Flight Sciences.
COMPUTATIONAL PROCEDURES FOR EVALUATING THE SENSITIVITY DERIVATIVES OF VIBRATION FREQUENCIES AND EIGENMODES OF FRAMED STRUCTURES
TIMOTHY L. FETTERMAN and AHMED K. NOOR Washington NASA Oct. 1987 88 p
(Contract NAG1-728)
(NASA-CR-4099; NAS 1.26:4099) Avail: NTIS HC A05/MF A01 CSCL 20K

Computational procedures are presented for evaluating the sensitivity derivatives of the vibration frequencies and eigenmodes of framed structures. Both a displacement and a mixed formulation are used. The two key elements of the computational procedure are: (a) Use of dynamic reduction techniques to substantially reduce the number of degrees of freedom; and (b) Application of iterative techniques to improve the accuracy of the derivatives of the eigenmodes. The two reduction techniques considered are the static condensation and a generalized dynamic reduction technique. Error norms are introduced to assess the accuracy of the eigenvalue and eigenvector derivatives obtained by the reduction techniques. The effectiveness of the methods presented is demonstrated by three numerical examples. Author

04

THERMAL CONTROL

Includes descriptions of analytical techniques, passive and active thermal control techniques, external and internal thermal experiments and analyses and trade studies of thermal requirements.

A87-32175*# Texas A&M Univ., College Station.
DETERMINATION OF THE CROSS-SECTIONAL TEMPERATURE DISTRIBUTION AND BOILING LIMITATION OF A HEAT PIPE
G. P. PETERSON (Texas A & M University, College Station) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 1, April 1987, p. 189-192.
(Contract NAS8-4496)

A computer model is developed and verified which is capable of determining the cross-sectional temperature distribution within a heat pipe with an attached radiator fin; such heat pipes would be plugged into contact heat exchangers designed to carry heat from a space station habitation module to the radiator elements through a centralized fluid loop. The model can furnish information for determining the susceptibility of the monogroove heat pipe to boiling, as well as the location and magnitude of that boiling. O.C.

A87-32369
A THERMALLY-PUMPED HEAT TRANSPORT SYSTEM
TETSURO OGUCHI, MASAAKI MURAKAMI (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan), YASUSHI

SAKURAI, and HIROAKI MATSUDA (Mitsubishi Electric Corp., Kamakura Works, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 703-710.

This paper describes a new concept of heat transport system, the 'thermal pump system', which offers advantages with respect to the present state of heat transport technology. This system is a two-phase flow loop which consists of an evaporator, a condenser, two accumulators with pumping heaters and four check valves. R 11 is used as a working fluid. Condensed liquid is pumped up from the condenser to the evaporator by the driving force produced by pressure oscillation, which is generated by the periodic heating of the pumping heaters attached to the accumulators. The heat transport characteristics of the system were theoretically and experimentally investigated. The required heat for the liquid pumping and the means for reducing the pumping heat were analyzed. Temperature and pressure distributions under a certain amount of heat transfer rate were predicted by an operation model presented here. In the operation model, mass and heat conservation and pressure drop were taken into consideration. The prediction agreed well with the experimental data. Author

A87-32377
HIGH THERMAL CAPACITY EVAPORATOR AND CONDENSERS FOR SPACE STATION THERMAL CONTROL
HAN HWANGBO and W. S. MCEVER (MRJ, Inc., Oakton, VA) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 755-760.

Pumped two-phase thermal control systems have a number of advantages over conventional single phase systems such as used on the Shuttle Orbiter. These advantages include reduced weight and higher thermal efficiency. In contrast to single phase systems, however, a two-phase fluid loop is much more sensitive to the effects of a 0-gravity environment. At MRJ several promising concepts for evaporator and condenser design for 0-g operation have been investigated. In this paper the design and control concepts are discussed and results of performance analyses are presented. The proposed evaporator/condenser concepts are widely applicable to any thermal control system such as for laser mirror cooling that requires high heat flux capability with minimum mechanical complexity. Author

A87-32662
DEVELOPMENT STATUS OF A TWO-PHASE THERMAL MANAGEMENT SYSTEM FOR LARGE SPACECRAFT
TIMOTHY J. BLAND, ING-YOMN CHEN, and DAVID G. C. HILL (Sundstrand Corp., Rockford, IL) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986 9 p
(SAE PAPER 861828)

Design features and results from testing of a prototype components of a two-phase thermal management system (TPTMS) for the Space Station are summarized. The TPTMS is comprised of an evaporator (heat addition) loop and a condenser (heat rejection) loop, both of which interface through a rotary fluid management device (RFMD). System functions which are to transfer heat from the Station to space through radiators are described, noting methods which keep the RFMD hot end at a constant temperature to control the liquid temperatures inside the evaporator. The TPTMS has been configured to accommodate growth loads to avoid the need for future capacity upgrades. Results are provided from tests of prototype RFMD, condenser and back pressure regulator valve. The assembled prototype is to undergo hypergravity and microgravity flight tests on a KC-135 aircraft. M.S.K.

A87-32663* RCA Astro-Electronics Div., Princeton, N. J.
DESIGN OF AN ADVANCED TWO-PHASE CAPILLARY COLD PLATE
D. R. CHALMERS (RCA, Astro-Electronics Div., Princeton, NJ), E. J. KROLICZEK, and J. KU (OAO Corp., Greenbelt, MD) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 12 p. refs
(Contract NAS5-29248)
(SAE PAPER 861829)

The functional principles and implementation of capillary pumped loop (CPL) two phase heat transport system for various elements of the Space Station program are described. Circulation of the working fluid by the surface-tension forces in a fine-pore capillary wick is the core principle of CPL systems. The liquid, usually NH3 at the moment, is changed into a vapor by heat absorption at one end of the loop, and the vapor is carried back along the wick by the surface tension within the wick. NASA specifications and the results of mechanical and thermal tests for prototype cold plate and the capillary pump designs are outlined. The CPL is targeted for installation on free-flying platforms, attached payloads, and power subsystem thermal control systems. M.S.K.

A87-32665
ENVIRONMENTAL AVOIDANCE CONCEPTS FOR STEERABLE SPACE STATION RADIATORS
B. L. HEIZER, G. D. RHODES, S. D. GOO, and D. W. THORESON (Boeing Aerospace Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 13 p.
(SAE PAPER 861831)

The systems rotary fluid coupling (RFC) concepts being studied for the Space Station steerable radiators are described. Steerable radiators are needed to handle the large thermal loads of the Station. The control system logic must identify the current position of the radiator with respect to the sun, the orbital position of the Station, and the operating temperature of the system. The logic must include the capability of pointing the radiators to minimize environmental damage to the radiators, i.e., select the minimal thermal environment and/or an appropriate position during warm-up of the radiators during minimal load periods. Design features of five sensor arrays which are candidates for meeting the 10 yr lifetime without component replacement, indefinite life with replacement, and 99 percent reliability specifications are described, along with the tradeoff studies being used in the evaluations. M.S.K.

A87-32666* Hughes Aircraft Co., Torrance, Calif.
HIGH CAPACITY DEMONSTRATION OF HONEYCOMB PANEL HEAT PIPES
H. J. TANZER, M. R. CERZA, JR. (Hughes Aircraft Co., Torrance, CA), and J. B. HALL (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 18 p. refs
(SAE PAPER 861833)

High capacity honeycomb panel heat pipes were investigated as heat rejection radiators on future space platforms. Starting with a remnant section of honeycomb panel measuring 3.05-m long by 0.127-m wide that was originally designed and built for high-efficiency radiator fins, features were added to increase thermal transport capacity and thus permit test evaluation as an integral heat transport and rejection radiator. A series of subscale panels were fabricated and reworked to isolate individual enhancement features. Key to the enhancement was the addition of a liquid sideflow that utilizes pressure priming. A prediction model was developed and correlated with measured data, and then used to project performance to large, space-station size radiators. Results show that a honeycomb panel with 5.08-cm sideflow spacing and core modification will meet the design load of a 50 kW space heat rejection system. Author

A87-32668* Boeing Aerospace Co., Seattle, Wash.
PROTOTYPE THERMAL BUS FOR MANNED SPACE STATION COMPARTMENTS
RONALD C. ZENTNER (Boeing Aerospace Co., Seattle, WA) and JAMES W. OWEN (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 13 p.
(SAE PAPER 861825)

A summary is presented of NASA efforts, to February 1986, on development of an advanced thermal bus for manned spacecraft. Design details are described for a prototype to be tested in 1987 that includes a contact heat exchanger, an air cooling heat exchanger for manned cabin conditions, and an interface heat exchanger for transferring compartment heat loads to the Space Station Central Thermal Bus. The design and performance criteria defined for the thermal bus are outlined and results are reported from comparisons of the capabilities and operational costs of pumped water and two-phase evaporating/condensing heat transport concepts. The operating temperature, launch weight/thermal performance ratios, and power requirements of each concept are discussed, along with the critical technologies identified for use of a water/titanium two-phase thermal bus. M.S.K.

A87-34469*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THERMAL DESIGN OF THE ACCESS ERECTABLE SPACE TRUSS

OBIE H. BRADLEY, JR. and RICHARD A. FOSS (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Mar.-Apr. 1987, p. 188-192. Previously cited in issue 17, p. 2472, Accession no. A85-37658. refs

A87-38725

THE CAPABILITIES OF EURECA THERMAL CONTROL FOR FUTURE MISSION SCENARIOS

B. SCHWARZ, K. BECKMANN, D. STUEMPEL (MBB-ERNO Raumfahrttechnik GmbH, Bremen, West Germany), and P. TAMBURINI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 225-233.
(SAE PAPER 860936)

Attention is given to the thermal control system configuration and functions of the European Retrievable Carrier (Eureca) spacecraft, which will be lofted into orbit by the NASA Space Shuttle in 1988 and is designed to perform a total of five free-flying missions of 6-month duration initially. Future missions, however, will entail extended lifetimes and a purely passive Thermal Control Subsystem design. The requirements of the Eureca Sophys solar region studies mission and Gretel X- and gamma-ray detection mission. O.C.

A87-38734* United Technologies Corp., Windsor Locks, Conn.

REGENERABLE NON-VENTING THERMAL CONTROL SUBSYSTEM FOR EXTRAVEHICULAR ACTIVITY

GEORGE J. ROEBELEN, STEPHEN A. BAYES (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), and B. MIKE LAWSON (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 345-355.
(SAE PAPER 860947)

Routine and complex EVAs call for more effective heat rejection systems in order to maximize mission productivity; an optimum EVA mobility unit (EMU) thermal control subsystem must require no expendables and introduce no contaminants into the environment, while conforming to minimum size limits and allowing easy regeneration. Attention is presently given to two thermal control subsystems, one of which can be integrated with the existing Space Shuttle Orbiter EMU to provide a 3-hour nonventing heat rejection capability, while the other can furnish the entire heat rejection capability requirement for an 8-hour Space Station EVA. O.C.

A87-38743

QUALITY MONITORING IN TWO-PHASE HEAT TRANSPORT SYSTEMS FOR LARGE SPACECRAFT

A. A. M. DELIL (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 439-452. refs
(SAE PAPER 860959)

Two-phase heat transport systems are currently considered for the thermal management of future large power spacecraft. The monitoring of the quality, being the relative vapor mass content, of the two-phase mixture at various locations in the system, is valuable - possibly indispensable - for the proper operation of such a system. This paper reviews concepts for quality monitoring. Only a few concepts turn out to be suitable for spacecraft applications. Promising concepts are based on the capacitance, sonic velocity and index of refraction. These concepts are described and quantitatively analyzed. Applicability, advantages, restrictions and some hardware aspects are discussed. Author

A87-38760

ENHANCED EVAPORATIVE SURFACE FOR TWO-PHASE MOUNTING PLATES

M. G. GROTE, J. A. STARK, and E. C. TEFFT, III (McDonnell Douglas Corp., Saint Louis, MO) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 617-626.
(SAE PAPER 860979)

An enhancement method for a grooved, evaporative surface for two-phase mounting plates which could be used in two-phase thermal control systems, such as that on the proposed Space Station is presented. An aluminum plate is machined with fine, rectangular grooves (39 grooves/cm). This grooved surface is then enhanced by an inexpensive process called Ivadizing, during which aluminum is vapor-deposited onto the surface, forming a slightly porous coating on the area between the grooves. The resulting surface has a much larger evaporative heat transfer coefficient and capillary pumping ability than that of plain rectangular grooves. Tests of this plate with R-11 showed improvement in evaporative heat transfer coefficient by a factor of 4. Analytic studies show that this enhanced surface should have at least three times the capillary pumping capacity of the rectangular grooved surface. Author

A87-38775* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EVALUATION OF SPACE STATION THERMAL CONTROL TECHNIQUES

J. B. HALL (NASA, Langley Research Center, Hampton, VA), GENE T. COLWELL, and JAMES G. HARTLEY (Georgia Institute of Technology, Atlanta) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 791-804. refs
(SAE PAPER 860998)

A procedure is developed for evaluating various candidates for thermal control in the orbiting Space Station. Candidates for acquisition, transport and rejection are considered. For example, thermal rejection candidates include heat pipe radiators, high capacity heat pipe radiators and liquid droplet radiators. A computer program has been developed which computes subsystem and total system weights, volumes, powers and costs for a system consisting of selected acquisition, transport and rejection candidates. The program user is also able to select mission parameters such as duration, resupply interval, thermal loads, transport distance, acquisition temperature and rejection temperature. Simulation models are included in the program which allow the user to change candidate designs. For example, for a high capacity heat pipe radiator the user may change working fluid, materials, radiator temperature, radiator geometry, surface emissivity and surface absorptivity. The program also allows the selection of several different acquisitions of thermal energy at different temperatures using different acquisition candidates. Author

A87-38776
OPTIMIZATION OF HEAT REJECTION SUBSYSTEM FOR SOLAR DYNAMIC BRAYTON CYCLE POWER SYSTEM
RICHARD PEARSON and DAVID DABROWSKI (Grumman Aerospace Corp., Bethpage, NY) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 805-815.
(SAE PAPER 860999)

A closed Brayton cycle (CBC) powerplant is under consideration for the Space Station Solar Dynamic Power System; attention is presently given to the weight, volume and cost optimization of the CBC's heat rejection system, on whose performance the power generation efficiency of the entire apparatus is strongly dependent. An analysis of the effects of varying system parameters on the radiator area and weight requirement indicates that radiator area is strongly dependent on radiator physical design. Radiator size depends on the arrangement, size, and design point heat rejection of the radiator panels, as well as such radiator properties as fin effectiveness, emissivity, and absorptivity. O.C.

A87-43003#
SPACE STATION ACTIVE THERMAL CONTROL SYSTEM MODELLING
ROSEMARY SCHMIDT and ERIC GUSTAFSON (Grumman Aerospace Corp., Space Systems Div ., Bethpage, NY) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 8 p.
(AIAA PAPER 87-1468)

This paper describes a unique thermal modelling method that was devised to model the Grumman design of the Space Station Active Thermal Control System (ATCS). The ATCS utilizes a two-phase thermal bus for acquiring and transporting heat to heat pipe radiators, which reject the waste heat to space. The mathematical modelling and analysis of these systems required the development of new modelling methods. The SINDA thermal analyzer program was used for the modelling, but since this program has no two-phase flow analysis capability, several additional routines were developed. These routines were then used in conjunction with the SINDA thermal analyzer for modelling the two-phase flow in the thermal bus. This work was performed for NASA as part of the Space Station Work Package 2 phase B study. Author

A87-43014#
THE BENEFIT OF PHASE CHANGE THERMAL STORAGE FOR SPACECRAFT THERMAL MANAGEMENT
M. S. BUSBY and S. J. MERTESDORF (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 8 p. refs
(AIAA PAPER 87-1482)

This paper discusses the applications of thermal storage in spacecraft which are beneficial for weight savings. Tools are developed which allow a thermal system designer to perform preliminary thermal performance and weight trades on systems with thermal storage and those without. Thermal storage module designs which achieve high performance are also discussed. Analysis is performed to assess the impact of two heating profiles representative of typical spacecraft missions: a pulse power profile and the absolute value of a sinusoidal profile. The pulse power profile is typical of surveillance spacecraft dissipation and the sinusoidal profile represents solar heating. Using the tools developed in the paper, it was found that thermal storage can be valuable in reducing the system weight for pulsed heating with short pulse duration and for solar heating with short orbit periods. Author

A87-43048*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID SHEET RADIATOR
DONALD L. CHUBB and K. ALLAN WHITE, III (NASA, Lewis Research Center, Cleveland, OH) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 12 p. Previously announced in STAR as N87-18786. refs
(AIAA PAPER 87-1525)

A new external flow radiator concept, the liquid sheet radiator (LSR), is introduced. The LSR sheet flow is described and an expression for the length/width (l/w) ratio is presented. A linear dependence of l/w on velocity is predicted that agrees with experimental results. Specific power for the LSR is calculated and is found to be nearly the same as the specific power of a liquid droplet radiator (LDR). Several sheet thicknesses and widths were experimentally investigated. In no case was the flow found to be unstable. Author

A87-43059*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID DROPLET RADIATOR DEVELOPMENT STATUS
K. ALAN WHITE, III (NASA, Lewis Research Center, Cleveland, OH) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 21 p. Previously announced in STAR as N87-20353. refs
(AIAA PAPER 87-1537)

Development of the Liquid Droplet Radiator (LDR) is described. Significant published results of previous investigators are presented, and work currently in progress is discussed. Several proposed LDR configurations are described, and the rectangular and triangular configurations currently of most interest are examined. Development of the droplet generator, collector, and auxiliary components are discussed. Radiative performance of a droplet sheet is considered, and experimental results are seen to be in very good agreement with analytical predictions. The collision of droplets in the droplet sheet, the charging of droplets by the space plasma, and the effect of atmospheric drag on the droplet sheet are shown to be of little consequence, or can be minimized by proper design. The LDR is seen to be less susceptible than conventional technology to the effects of micrometeoroids or hostile threats. The identification of working fluids which are stable in the orbital environments of interest is also made. Methods for reducing spacecraft contamination from an LDR to an acceptable level are discussed. Preliminary results of microgravity testing of the droplet generator are presented. Possible future NASA and Air Force missions enhanced or enabled by a LDR are also discussed. System studies indicate that the LDR is potentially less massive than heat pipe radiators. Planned microgravity testing aboard the Shuttle or space station is seen to be a logical next step in LDR development. Author

A87-43103*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THE DEFINITION OF THE LOW EARTH ORBITAL ENVIRONMENT AND ITS EFFECT ON THERMAL CONTROL MATERIALS
J. T. DURCANIN, D. R. CHALMERS (RCA Aerospace and Defense, RCA Astro-Space Div., Princeton, NJ), and J. T. VISENTINE (NASA, Johnson Space Center, Houston, TX) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 13 p. refs
(AIAA PAPER 87-1599)

The LEO environment and its effects on thermal-control materials (TCMs) being evaluated for use in long-term-mission space structures such as the Space Station are characterized, summarizing the results of recent space and laboratory experiments. Factors examined include atomic oxygen (a serious problem out to 600-700 km), ionizing radiation, solar UV radiation, solid particles (manmade debris and micrometeoroids, a significant hazard out to about 1000 km), and synergistic effects. Numerical data on the expected intensity of these effects for the different

Space Station components, the resistance of specific TCMs to the effects, and the effectiveness of protective coatings are compiled in extensive tables and illustrated with diagrams, graphs, and micrographs. T.K.

A87-43125*# Grumman Aerospace Corp., Bethpage, N.Y.

THERMAL TEST RESULTS OF THE TWO-PHASE THERMAL BUS TECHNOLOGY DEMONSTRATION LOOP

FRED EDELSTEIN, MARIA LIANDRIS (Grumman Aerospace Corp., Bethpage, NY), and J. GARY RANKIN (NASA, Johnson Space Center, Houston, TX) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 9 p. refs
(AIAA PAPER 87-1627)

A two-phase heat transport system, the Thermal Bus Technology Demonstrator, has been built and tested for NASA Johnson Space Center for application on Space Station. The loop is a separated two-phase system that uses evaporator flow control valves and liquid condenser flooding to achieve temperature control. Both ambient and thermal vacuum tests have been completed in NASA's Chamber A, initially using Freon-11 and then ammonia as the working fluid. Overall, the tests were quite successful, with the bus achieving all major test objectives, including operation at 19.5 kW and set points at 35 F (1.7 C), 70 F (21.1 C) and 104 F (40.0 C), load sharing, asymmetrical heating and isothermality around the loop. Low plate to vapor temperature drops were obtained for the monogroove cold plate using ammonia and are indicative of the high evaporative film coefficients obtainable with this design. Author

A87-43126*# Boeing Aerospace Co., Seattle, Wash.

DEVELOPMENT OF A PROTOTYPE TWO-PHASE THERMAL BUS SYSTEM FOR SPACE STATION

D. L. MYRON (Boeing Aerospace Co., Seattle, WA) and R. C. PARISH (NASA, Johnson Space Center, Houston, TX) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 11 p. refs
(AIAA PAPER 87-1628)

This paper describes the basic elements of a pumped two-phase ammonia thermal control system designed for microgravity environments, the development of the concept into a Space Station flight design, and design details of the prototype to be ground-tested in the Johnson Space Center (JSC) Thermal Test Bed. The basic system concept is one of forced-flow heat transport through interface heat exchangers with anhydrous ammonia being pumped by a device expressly designed for two-phase fluid management in reduced gravity. Control of saturation conditions, and thus system interface temperatures, is accomplished with a single central pressure regulating valve. Flow control and liquid inventory are controlled by passive, nonelectromechanical devices. Use of these simple control elements results in minimal computer controls and high system reliability. Building on the basic system concept, a brief overview of a potential Space Station flight design is given. Primary verification of the system concept will involve testing at JSC of a 25-kW ground test article currently in fabrication. Author

A87-44830*# Washington Univ., Seattle.

RADIATION HEAT TRANSFER CALCULATIONS FOR SPACE STRUCTURES

A. F. EMERY, O. JOHANSSON, and A. ABROUS (Washington, University, Seattle) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 7 p. refs
(Contract NAG1-41)
(AIAA PAPER 87-1522)

A method is presented for the computation of radiant heat flux between arbitrary surfaces which permits a user defined level of accuracy. The method can be applied to directionally dependent surface properties, specular radiation, or solar illumination, and ensures conservation of energy. The method is compared with others to demonstrate its value. Author

A87-44843*# General Dynamics Corp., San Diego, Calif.

STRUCTURAL AND PRELIMINARY THERMAL PERFORMANCE TESTING OF A PRESSURE ACTIVATED CONTACT HEAT EXCHANGER

C. Y. LEE, E. L. CHRISTIAN, J. W. WOHLWEND (General Dynamics Corp., Space Systems Div., San Diego, CA), and R. C. PARISH (NASA, Johnson Space Center, Houston, TX) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 9 p.
(AIAA PAPER 87-1540)

A contact heat exchanger concept is being developed for use onboard Space Station as an interface device between external thermal bus and pressurized modules. The concept relies on mechanical contact activated by the fluid pressure inside thin-walled tubes. Structural testings were carried out to confirm the technology feasibility of using such thin-walled tubes. The test results also verified the linear elastic stress analysis which was used to predict the tube mechanical behaviors. A preliminary thermal testing was also performed with liquid Freon-11 flowing inside tubes and heat being supplied by electrical heating from the bottom of the contact heat exchanger baseplate. The test results showed excellent agreement of test data with analytical prediction for all thermal resistances except for the two-phase flow characteristics. Testing with two-phase flow inside tubes will, however, be performed on the NASA-JSC test bed. Author

A87-45258#

THERMAL DESIGN OF A LARGE SPACECRAFT PROPULSION SYSTEM

J. E. GENOVESE and J. L. GODWARD (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 7 p.
(AIAA PAPER 87-1863)

A spacecraft propulsion system consisting of two propellant tanks capable of carrying 1900 pounds of hydrazine, six helium pressurant tanks, and 12 five-pound thrusters has been designed and qualified for an orbit transfer and station-keeping mission. The baseline mission imposed a severe power constraint on the thermal control subsystem. Attaining the power goal was complicated by the large size of the propulsion system and the severity of the environments. A thermal design evolved which incorporated the use high strength, low thermal conductivity titanium struts, multilayer insulation blankets with integral propulsion bay vents, and thermostatically controlled heaters. The ability to maintain all components within required temperature ranges was subsequently verified during thermal balance testing. Based on this testing, the orbital average power consumption of the thermal control subsystem is estimated to be less than 32 watts. Author

A87-48882

EVALUATION OF THE INFRARED TEST METHOD FOR THE OLYMPUS THERMAL BALANCE TESTS

MARC DONATO, JERRY GREEN, DANY ST-PIERRE (Spar Aerospace, Ltd., Ste-Anne-de-Bellevue, Canada), and MURRAY REEVES (David Florida Laboratory, Ottawa, Canada) Journal of Environmental Sciences (ISSN 0022-0906), vol. 30, May-June 1987, p. 45-49. Research supported by the Canadian Department of Communications and Olympus Program.

The present work reports on the performance of the infrared test techniques developed and used for the thermal balance testing of the Olympus spacecraft thermal model. Developments in the area of computer software, radiometers, and temperature measurement systems are presented. The power control and data acquisition systems are detailed. A summary of the test results shows that temperature differences between test and predictions are in agreement within the values obtained in past programs for an uncorrelated mathematical model. Author

N87-20353*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LIQUID DROPLET RADIATOR DEVELOPMENT STATUS

K. ALAN WHITE, III 1987 28 p Prepared for presentation at

the 22nd Thermophysics Conference, Honolulu, Hawaii, 8-10 Jul. 1987; sponsored by AIAA
(NASA-TM-89852; E-3510; NAS 1.15:89852) Avail: NTIS HC A03/MF A01 CSCL 22B

Development of the Liquid Droplet Radiator (LDR) is described. Significant published results of previous investigators are presented, and work currently in progress is discussed. Several proposed LDR configurations are described, and the rectangular and triangular configurations currently of most interest are examined. Development of the droplet generator, collector, and auxiliary components are discussed. Radiative performance of a droplet sheet is considered, and experimental results are seen to be in very good agreement with analytical predictions. The collision of droplets in the droplet sheet, the charging of droplets by the space plasma, and the effect of atmospheric drag on the droplet sheet are shown to be of little consequence, or can be minimized by proper design. The LDR is seen to be less susceptible than conventional technology to the effects of micrometeoroids or hostile threats. The identification of working fluids which are stable in the orbital environments of interest is also made. Methods for reducing spacecraft contamination from an LDR to an acceptable level are discussed. Preliminary results of microgravity testing of the droplet generator are presented. Possible future NASA and Air Force missions enhanced or enabled by a LDR are also discussed. System studies indicate that the LDR is potentially less massive than heat pipe radiators. Planned microgravity testing aboard the Shuttle or space station is seen to be a logical next step in LDR development. Author

N87-21021*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ANALYSIS OF ON-ORBIT THERMAL CHARACTERISTICS OF THE 15-METER HOOP/COLUMN ANTENNA

GREGORY C. ANDERSEN, JEFFERY T. FARMER, and JAMES GARRISON (Rensselaer Polytechnic Inst., Troy, N.Y.) Mar. 1987 33 p
(NASA-TM-89137; NAS 1.15:89137) Avail: NTIS HC A03/MF A01 CSCL 22B

In recent years, interest in large deployable space antennas has led to the development of the 15 meter hoop/column antenna. The thermal environment the antenna is expected to experience during orbit is examined and the temperature distributions leading to reflector surface distortion errors are determined. Two flight orientations corresponding to: (1) normal operation, and (2) use in a Shuttle-attached flight experiment are examined. A reduced element model was used to determine element temperatures at 16 orbit points for both flight orientations. The temperature ranged from a minimum of 188 K to a maximum of 326 K. Based on the element temperatures, orbit position leading to possible worst case surface distortions were determined, and the subsequent temperatures were used in a static finite element analysis to quantify surface control cord deflections. The predicted changes in the control cord lengths were in the submillimeter ranges. Author

N87-26072*# Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering.

DEVELOPMENT OF AN EMULATION-SIMULATION THERMAL CONTROL MODEL FOR SPACE STATION APPLICATION Semiannual Status Report

JAMES G. HARTLEY and GENE T. COLWELL Jun. 1987 80 p
(Contract NAG1-551)
(NASA-CR-181009; NAS 1.26:181009) Avail: NTIS HC A05/MF A01 CSCL 22B

An improved capability for comparing various techniques for thermal management in the Space Station was developed. Current planning for the orbiting space station calls for a dual keel configuration. The thermal control system (TCS) for the space is composed of a central TCS and internal thermal control systems for the modules, as well as service facilities and attached payloads. The internal TCS may be attached to the central TCS through a thermal bus. The central TCS is composed of a main transport system which collects waste thermal energy from each of the modules and transports it through coolant lines to the main rejection system. The waste heat loads in the modules arise from electrical and electronic equipment as well as metabolic loads in the manned modules. Several candidate technologies are being considered for acquiring the waste heat loads, for transporting the thermal energy between the acquisition and rejection systems, and for rejecting the waste heat to space. The analysis techniques described were developed for use in evaluating reliability, weights, costs, volumes, and power requirements for configurations using different candidates and different mission parameters. Author

N87-26192*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AN ELECTRICALLY CONDUCTIVE THERMAL CONTROL SURFACE FOR SPACECRAFT ENCOUNTERING LOW-EARTH ORBIT (LEO) ATOMIC OXYGEN INDIUM TIN OXIDE-COATED THERMAL BLANKETS Abstract Only

J. L. BAUER *In its* Proceedings of the NASA Workshop on Atomic Oxygen Effects p 156 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 22B

An organic black thermal blanket material was coated with indium tin oxide (ITO) to prevent blanket degradation in the low Earth orbit (LEO) atomic oxygen environment. The blankets were designed for the Galileo spacecraft. Galileo was initially intended for space shuttle launch and would, therefore, have been exposed to atomic oxygen in LEO for between 10 and 25 hours. Two processes for depositing ITO are described. Thermooptical, electrical, and chemical properties of the ITO film are presented as a function of the deposition process. Results of exposure of the ITO film to atomic oxygen (from a shuttle flight) and radiation exposure (simulated Jovian environment) are also presented. It is shown that the ITO-protected thermal blankets would resist the anticipated LEO oxygen and Jovian radiation yet provide adequate thermooptical and electrical resistance. Reference is made to the ESA Ulysses spacecraft, which also used ITO protection on thermal control surfaces. Author

N87-20936* Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering.

DEVELOPMENT OF AN EMULATION-SIMULATION THERMAL CONTROL MODEL FOR SPACE STATION APPLICATION Semiannual Status Report

JAMES G. HARTLEY and GENE T. COLWELL Oct. 1986 63 p
(Contract NAG1-551)
(NASA-CR-180312; NAS 1.26:180312) Avail: NTIS HC A04/MF A01 CSCL 22B

The orbiting space station being developed by NASA will have many thermal sources and sinks as well as requirements for the transport of thermal energy through large distances. The station is also expected to evolve over twenty or more years from an initial design. As the station evolves, thermal management will become more difficult. Thus, analysis techniques to evaluate the effects of changing various thermal loads and the methods utilized to control temperature distributions in the station are essential. Analysis techniques, including a user-friendly computer program, were developed which should prove useful to thermal designers and system analysts working on the space station. The program uses a data base and user input to compute costs, sizes, and power requirements for individual components and complete systems. User input consists of selecting mission parameters, selecting thermal acquisition configurations, transport systems and distances, and thermal rejection configurations. The capabilities of the program may be expanded by including additional thermal models as subroutines. Author

N87-27702*# Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering.

DEVELOPMENT OF AN EMULATION-SIMULATION THERMAL CONTROL MODEL FOR SPACE STATION APPLICATION Semiannual Status Report

GENE T. COLWELL and JAMES G. HARTLEY Jul. 1987 11 p
(Contract NAG1-551)

(NASA-CR-181221; NAS 1.26:181221) Avail: NTIS HC A02/MF A01 CSCL 22B

Many features were added to the Thermal Control System (TCS) program to increase its user-friendliness. Several apparent inconsistencies were identified. In some instances, these have led to modifications to the source programs. With the summary line-sizing information, the user can more readily compare the TCS program results with other available data. Two mathematical models were completed: one deals with sizing and analysis of bus heat exchangers and the other provides a means of analyzing a variety of heat pipe radiator designs. A generic heat pipe model was added to the TCS Analysis Program. B.G.

N87-29217# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

THE LIQUID DROPLET RADIATOR IN SPACE: A PARAMETRIC APPROACH M.S. Thesis

GERALD L. BUCKNER Mar. 1987 72 p
(AD-A182605; AFIT/GNE/ENP/87M-1) Avail: NTIS HC A04/MF A01 CSCL 12B

A successful space mission must have a source of electrical power whether the mission is manned, unmanned, scientific, or nationally strategic. The generation of this electric power will require the rejection of waste heat. For example, the Strategic Defense Initiative will have space based systems generating large amounts of electrical energy with much waste heat energy to be radiated to space. Other space applications requiring from 100 kilowatts to over 100 megawatts include: Space Based Radars, Nuclear/Electric Orbital Transfer Vehicles, Space Based Weapon Systems, and the Space Station. The objective of this study was to investigate the performance and operating characteristics of a cylindrical LDR for use in space by minimizing the mass per heat radiated as a function of the average droplet temperature at the collector using a new pump specific mass term defined as pump mass per liquid mass flow rate. GRA

05

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

Includes description of analytical techniques and models, trade studies of technologies, subsystems, support strategies, and experiments for internal and external environmental control and protection, life support systems, human factors, life sciences and safety.

A87-32455

PRELIMINARY EXPERIMENTAL STUDY ON THE OXYGEN SEPARATING AND CONCENTRATING SYSTEM FOR CELSS

SHUJI KANDA, HIROYUKI MATSUMURA, TAKATOSHI SHOJI (Kawasaki Heavy Industries, Ltd., Kobe, Japan), KEIJI NITTA, KOHJI OHTSUBO (National Aerospace Laboratory, Chofu, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1337-1341. refs

A system which uses Salcomine (ethoxy salicylaldehyde ethylene diamine cobalt) to separate and concentrate the oxygen produced in a CELSS for the Space Station is described. The Salcomine absorbs the oxygen under normal temperatures (less than 40 C) and desorbs oxygen under temperatures higher than 80 C. The concept of CELSS is reviewed and a diagram of a CELSS is provided. The operation of the gas recycle system, which is utilized as a reservoir in the CELSS to compensate for the difference between the gas production and consumption, is examined. The ability of the Salcomine to absorb or desorb oxygen is evaluated for Salcomine alone and Salcomine in a canister. It is observed that the oxygen absorbing capacity of the Salcomine is about 4.0 percent for Salcomine alone and about 2.7 percent for Salcomine in a canister. Diagrams of the proposed gas recycle system and oxygen separating and concentration system are presented. I.F.

A87-32457

GAS AND WATER RECYCLING SYSTEM FOR IOC VIVARIUM EXPERIMENTS

KOJI OTSUBO, KEIJI NITTA, MITSUO OGUCHI, SIGERU HAYASHI, SHIGEKI HATAYAMA (National Aerospace Laboratory, Chofu, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1349-1354. Research supported by the Japanese CELSS Research Group. refs

A design for a gas and water recycling system to support life science missions at the initial operational capability of the Space Station is proposed. The gas recycling subsystem is composed of: prefilters to remove harmful gas; canister units for CO2 and O2 gas content control; humidifiers; gas bottles; and a controller. The operation of the subsystem, which is to remove CO2 gas from the outlet air of the animal vivariums and to remove excessive O2 gas from the outlet air of the phytotron and algae cultivator, is described. The water recycling subsystem is to use a high polymer membrane filtration unit and a distiller to purify the water; the roles of the microfilter, ultrafilter, and reverse osmosis filters of the membrane filtration unit are examined. Diagrams of the two subsystems are provided. I.F.

A87-32458

WATER RECYCLING SYSTEM USING THERMOPERVAPORATION METHOD

KATSUYA EBARA, HIDEAKI KUROKAWA, AKIRA YAMADA, YASUO KOSEKI (Hitachi, Ltd., Hitachi Research Laboratory, Japan), and AKIRA ASHIDA (Hitachi, Ltd., Space Systems Div., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1355-1359. refs

A space station water recycling system is evaluated on the basis of fundamental experiments and simulated calculations of absorption-type thermopervaporation. The specific electric conductivity of the treated water was below 10 microS/cm, and the coefficient of permeation through the membrane was more than 1 kg/sq m day mm Hg. The optimum operating conditions for the recycling system are presented. K.K.

A87-32459

WATER RECYCLING FOR SPACE STATION

KENJI MITANI, AKIRA ASHIDA (Hitachi, Ltd., Space Systems Div., Tokyo, Japan), KATSUYA EBARA (Hitachi, Ltd., Hitachi Research Laboratory, Japan), and KEIJI NITTA (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1361-1364.

A system configuration, based on membrane-based technology, for water recycling in the Space Station is proposed to purify water wastes produced by both the crew and the facilities of life science experiments. A three-step filtration process consisting of prefiltration, ultrafiltration and reverse osmosis provides water for showers and the life science experiments. A portion of the permeate from the reverse osmosis process is further processed by a thermopervaporation membrane technique to provide potable water. Ground experimental equipment for the water recycling system for the IOC Japanese life science experiments is described. R.R.

A87-32544

CONCEPT STUDY OF REGENERABLE CARBON DIOXIDE REMOVAL AND OXYGEN RECOVERY SYSTEM FOR THE SPACE STATION

K. OTSUJI, T. SAWADA (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Japan), S. SATOU, and M. MINEMOTO (Mitsubishi

Heavy Industries, Ltd., Takasago Technical Institute, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2007-2016. refs

Results are presented from Japanese studies of technologies for an atmosphere regeneration system (ARS) for the Space Station. The choice is between solid amine systems with either ion exchange resin (IER) or an amine impregnated adsorbent (AIA). IER Systems contain amino radicals that ion exchanges HCO3(-) produced by CO2 and atmosheric moisture. AIA systems holding a polyethylene-resin, potassium-n-methyl alaninate or other amine directly adsorb CO2 from the air. In the IER, CO2 is desorbed by steam heating, while in the AIA, CO2 is desorbed by heating or vacuum sucking. Experimental versions of the two types of ARSs are described, along with data indicating a preferred steam cannister configuration, a greater CO2 absorbancy of the IER relative to the AIA system, and lower energy requirements with steam regeneration. The principles of the Bosch and Sabatier processes for oxygen recovery are reviewed, and test data which indicate areas requiring further development are identified.

M.S.K.

A87-32632

COMPUTER SIMULATION OF ON-ORBIT MANNED MANEUVERING UNIT OPERATIONS

GARY M. STUART and KATHY D. GARCIA (Martin Marietta Corp., Bethesda, MD) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 7 p. Previously announced in STAR as N87-12245.
(SAE PAPER 861783)

Simulation of spacecraft on-orbit operations is discussed in reference to Martin Marietta's Space Operations Simulation laboratory's use of computer software models to drive a six-degree-of-freedom moving base carriage and two target gimbal systems. In particular, key simulation issues and related computer software models associated with providing real-time, man-in-the-loop simulations of the Manned Maneuvering Unit (MMU) are addressed with special attention given to how effectively these models and motion systems simulated the MMU's actual on-orbit operations. The weightless effects of the space environment require the development of entirely new devices for locomotion. Since the access to space is very limited, it is necessary to design, build, and test these new devices within the physical constraints of earth using simulators. The simulation method that is discussed here is the technique of using computer software models to drive a Moving Base Carriage (MBC) that is capable of providing simultaneous six-degree-of-freedom motions. This method, utilized at Martin Marietta's Space Operations Simulation (SOS) laboratory, provides the ability to simulate the opertion of manned spacecraft, provides the pilot with proper three-dimensional visual cues, and allows training of on-orbit operations. The purpose here is to discuss significant MMU simulation issues, the related models that were developed in response to these issues and how effectively these models simiate the MMU's actual on-orbiter operations. Author

A87-33013

A COMPARISON BETWEEN SPACE SUITED AND UNSUITED REACH ENVELOPES

J. H. STRAMLER (Northrop Services, Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 221-224.

A comparison was made for the reach capability of Shuttle space suit vs unsuited. Graphics were generated and reach envelope volumes computed. The space suit reduces the reach envelope volume from about 64 to 97 percent, depending on the type of envelope measured. Author

A87-36600

WHEN THE DOCTOR IS 200 MILES AWAY

LES DORR, JR. Space World (ISSN 0038-6332), vol. X-3-279, March 1987, p. 33-36.

Severe medical problems which may be encountered by crewmembers during Space Station tours of duty are discussed, as are the capabilities planned for the Station Health Maintenance Facility (HMF). Heart muscles lose tone and mass during long periods in microgravity, and bones inexorably lose calcium in a demineralization process. An increasing frequency of humans spending long periods of time in space introduces the possibility of occurrence of acute illnesses such as cardiovascular problems or kidney stones precipitating from bone calcium suspended in the blood. A prototype HMF has a defibrillator, ECG, pulse oximeter, patient restraints, CRT readouts, an IV system capable of long-term use, and exercise apparatus to offset the deconditioning effects of long-term spaceflight. All the equipment will be amenable to use by astronauts with paramedic training. M.S.K.

A87-36706* Vigyan Research Associates, Inc., Hampton, Va.

EFFECTS OF VARYING ENVIRONMENTAL PARAMETERS ON TRACE CONTAMINANT CONCENTRATIONS IN THE NASA SPACE STATION REFERENCE CONFIGURATION

DANA A. BREWER (Vigyan Research Associates, Inc., Hampton, VA) and JOHN B. HALL, JR. (NASA, Langley Research Center, Hampton, VA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 57-66. refs
(Contract NAS1-550; NAS1-17919)
(SAE PAPER 860916)

An evaluation is made of the NASA Space Station Reference Configuration trace contaminant production and depletion level effects of CO2, O2, humidity, temperature, and pressure variations, on the basis of a computer model of the Reference Configuration's chemical reactions and physical processes as functions of time. The effects of changes in the initial concentrations of such contaminants as nonmethane hydrocarbons and nitrogen oxides are also examined, and these are found to result in more significant changes in the concentration levels of trace contaminants than pressure and humidity variations. O2 and CO2 changes are found to have negligible effects on trace contaminant concentrations.

O.C.

A87-36712 Life Systems, Inc., Cleveland, Ohio.

A SPACE STATION UTILITY - STATIC FEED ELECTROLYZER

J. T. LARKINS, R. C. WAGNER, and M. L. GOPIKANTH (Life Systems, Inc., Cleveland, OH) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 97-107. Research supported by Life Systems, Inc. and NASA. refs
(SAE PAPER 860920)

The NASA Static Feed Electrolyzer (SFE), which will be used in the projected Space Station, has over the course of 18 years of development and testing refined its ancillary components and control and monitoring instrumentation. Space Station uses for the SFE are anticipated in environmental control and life support, electrical power systems, EVA, and the propulsion and reboost system. The commonalities among these four systems' requirements are presently examined. O.C.

A87-36716

FOODS AND NUTRITION IN SPACE

PAUL C. RAMBAUT (NIH, National Cancer Institute, Bethesda, MD) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 141-149. refs
(SAE PAPER 860926)

The present evaluation of manned space flight experience with nutritional effects on crew metabolism from Mercury to Mir indicates that low caloric intakes contributed in some measure to the biochemical and physiological changes observed in early flights, and that some deteriorative or adaptive processes accompanying space flight can affect nutritional requirements to the point where intakes appropriate in ground conditions become suboptimal. Body mass declines and the elemental constituents of bone and muscle continue to be lost. The assumption that humans require a diet of great complexity is reexamined in light of experimental evidence that individuals can be kept on a simple nutrient source for many years without ill effects. O.C.

A87-38728* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SPACE STATION FOOD SYSTEM

BEVERLY A. THURMOND (NASA, Johnson Space Center, Houston, TX), DOUGLAS J. GILLAN, MICHELE G. PERCHONOK (Lockheed Engineering and Management Services Co., Inc., Houston, TX), BETH A. MARCUS (Arthur D. Little, Inc., Cambridge, MA), and CHARLES T. BOURLAND (Technology, Inc., Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 179-183. refs
(SAE PAPER 860930)

A team of engineers and food scientists from NASA, the aerospace industry, food companies, and academia are defining the Space Station Food System. The team identified the system requirements based on an analysis of past and current space food systems, food systems from isolated environment communities that resemble Space Station, and the projected Space Station parameters. The team is resolving conflicts among requirements through the use of trade-off analyses. The requirements will give rise to a set of specifications which, in turn, will be used to produce concepts. Concept verification will include testing of prototypes, both in 1-g and microgravity. The end-item specification provides an overall guide for assembling a functional food system for Space Station. Author

A87-38729* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM DISTRIBUTION AND LOOP CLOSURE STUDIES

WILLIAM R. HUMPHRIES, JAMES L. REUTER, and RICHARD G. SCHUNK (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 285-296.
(SAE PAPER 860942)

The NASA Space Station's environmental control and life support system (ECLSS) encompasses functional elements concerned with temperature and humidity control, atmosphere control and supply, atmosphere revitalization, fire detection and suppression, water recovery and management, waste management, and EVA support. Attention is presently given to functional and physical module distributions of the ECLSS among these elements, with a view to resource requirements and safety implications. A strategy of physical distribution coupled with functional centralization is for the air revitalization and water reclamation systems. Also discussed is the degree of loop closure desirable in the initial operational capability status Space Station's oxygen and water reclamation loops. O.C.

A87-38730* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

STATUS OF THE SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM DESIGN CONCEPT

C. D. RAY and W. R. HUMPHRIES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 297-308.
(SAE PAPER 860943)

The current status of the Space Station (SS) environmental control and life support system (ECLSS) design is outlined. The concept has been defined at the subsystem level. Data supporting these definitions are provided which identify general configuratioons for all modules. Requirements, guidelines and assumptions used in generating these configurations are detailed. The basic 2 US module 'core' Space Station is addressed along with system synergism issues and early man-tended and future growth considerations. Along with these basic studies, also addressed here are options related to variation in the 'core' module makeup and more mature Station concepts such as commonality, automation and design to cost. Author

A87-38731* Life Systems, Inc., Cleveland, Ohio.

ENVIRONMENTAL CONTROL LIFE SUPPORT FOR THE SPACE STATION

CRAIG W. MILLER and LICIA S. KOVACH (Life Systems, Inc., Cleveland, OH) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 309-319. NASA-supported research.
(SAE PAPER 860944)

The preliminary design of the nation's Space Station is presently being developed. The Environmental Control and Life Support System (ECLSS), consisting of regenerative and nonregenerative technologies, has progressed through a series of trade studies including evaluation of the closure and distribution within the evolutionary Space Station configuration. The analysis has included the identification of the time-critical functions, redundancy (backup) management, definition of common subsystem interfaces and quantification of technology options for the process equipment. Each technology has been characterized by its physical characteristics of weight, power, volume, heat rejection, etc. Summaries of the trade study findings for the overall ECLSS in terms of physical characteristics and the impact of selected technologies is presented. Author

A87-38732

NUCLEAR POWERED SUBMARINES AND THE SPACE STATION - A COMPARISON OF ECLSS REQUIREMENTS

ROBERT N. ROSSIER (Martin Marietta Corp., Denver, CO) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 321-329.
(SAE PAPER 860945)

Both the NASA Space Station and current nuclear-powered submarines are required to sustain 90-day missions with their environmental control and life support systems (ECLSSs); their failure tolerance requirements are also similar. Detailed comparisons are presently undertaken for submarine and Space Station water, crew and power resources, pressurization requirements, shock and vibration environments, acoustics and noise considerations, external contamination prevention, and survivability. Subsystem design considerations encompass loop closure and the mass balance, reliability, CO2 removal and processing, oxygen generation, water recovery, atmospheric monitoring and contaminant control, waste management, and fire detection and suppression. O.C.

A87-38733* Life Systems, Inc., Cleveland, Ohio.

INTEGRATED AIR REVITALIZATION SYSTEM FOR SPACE STATION

R. B. BOYDA, C. W. MILLER (Life Systems, Inc., Cleveland, OH), and M. R. SCHWARTZ (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 331-343. NASA-supported research.
(SAE PAPER 860946)

Fifty-one distinct functions are encompassed by the Space Station's Environmental Control and Life Support System; one exception to this noninteractivity of functions is the regenerative air revitalization system that removes and reduces CO2 and generates O2. The integration of these interdependent functions, and of humidity control, into a single system furnishes opportunities for process simplification as well as for power, weight and volume requirement reductions by comparison with discrete subsystems. Attention is presently given to a system which quantifies these integration-related savings and identifies additional advantages that accrue to this integrating design method. O.C.

A87-38735

EVALUATION OF REGENERATIVE PORTABLE LIFE SUPPORT SYSTEM OPTIONS

JOSEPH A. CIOCCA (Grumman Corp., Space Systems Div., Bethpage, NY) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 357-365. refs
(SAE PAPER 860948)

An evaluation is made of the prospects for nonventing regenerative processes for Space Station application, in order to address the prohibitively high transportation costs associated with consumables resupply and the unacceptable contamination levels created by water-sublimating heat rejection devices. These regenerative processes are sought in CO2 removal, humidity control, and heat rejection; specific capacities as well as weight, volumes and power allocations are quantified for each of these categories, and representative packaging geometries are arrived at. Process interactions, candidate regeneration techniques, and potential cost savings are discussed. O.C.

A87-38736

SPACE STATION LIFE SUPPORT OXYGEN GENERATION BY SPE WATER ELECTROLYZER SYSTEMS

ALBERT C. ERICKSON and JAMES F. MCELROY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 367-373.
(SAE PAPER 860949)

Life support oxygen generation by water electrolysis is being considered for the Space Station program. On board oxygen generation from reclaimed water would be a major step toward closing the life support loop. An SPE electrolyzer, within which solid polymer membranes are the sole electrolyte, is a candidate for Space Station life support oxygen generation. The SPE electrolyzer, of the type currently qualified and in use for life support in nuclear submarines, has been modified for use in the zero gravity space environment. The proposed SPE electrolyzer configurations have addressed the difficulties of two phase separation and minimization of maintenance. Two variations of SPE electrolyzers are described. One for supplying oxygen and hydrogen at a few hundred psi for use within the space habitat, and one for supplying 3000 psi oxygen for the extravehicular mobility unit. Author

A87-38737

SPACE SUIT REACH AND STRENGTH ENVELOPE CONSIDERATIONS

ROBERT J. GRAY (ILC Industries, Inc., ILC Dover, Frederica, DE) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 375-381. refs
(SAE PAPER 860950)

Major difficulties exist in establishing a database for space-suited astronauts' reach and length; ideally, all such data should be obtained in a microgravity environment. Attention is presently given to the equipment and data presentation techniques formerly and currently used by NASA and the USAF in their human strength and reach capability researches. Future requirements for more detailed determinations of pressure suit capabilities are assessed and practical steps for the implementation of such experimental efforts are recommended. O.C.

A87-38738

DESIRABILITY OF ARMS-IN CAPABILITY IN SPACE SUITS

YVETTE M. BEGIAN (ILC Industries, Inc., ILC Dover, Frederica, DE) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 383-396. refs
(SAE PAPER 860951)

Retracting one or both arms from a space suit's sleeves into its torso has been envisioned as a means to enhance a crewperson's performance during repeated extended duration extravehicular activity (EVA). The purpose of this paper is to present considerations germane to the incorporation of an arm/arms-in feature in a space suit. It assesses what can be done with one and two arms-in; it presents the expected impacts to the wearer and the suit; and it discusses the operational feasibility of employing arm/arms-in. Author

A87-38749

LIFE SUPPORT SUBSYSTEM CONCEPTS FOR BOTANICAL EXPERIMENTS OF LONG DURATION

H. R. LOSER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 499-514. refs
(SAE PAPER 860967)

For botanical experiments with durations of several months (Eureca Botany Facility and Columbus Gravitational Biology Facility) consumables like water, carbon dioxide, oxygen, and phytotoxin-removal gas may contribute significantly to the weight of a Life Support Subsystem (LSS). Since the amount of such consumables has a significant influence on the optimum choice of the LSS, a literature survey has been performed to obtain realistic values which may be used for preliminary design purposes. Based on a comparison of the likely performance requirements of the LSS of orbital botanical facilities and the environmental control and life-support subsystem (ECLSS) of the carrier, various LSS concepts are discussed which interact to a varying degree with the ECLSS. Interaction means in this case that the ECLSS is used as a resource for the consumables needed by the LSS. Advantages and disadvantages of such interaction, in particular weight savings and technical complexity, are addressed. Author

A87-38750

AN EVOLUTIONARY APPROACH TO THE DEVELOPMENT OF A CELSS BASED AIR REVITALIZATION SYSTEM

ROBIN C. HUTTENBACH, MARTIN L. PRATT (Nelson Space Services, Ltd., England), and CHRIS BUCKE (LH Bioprocessing, Ltd., England) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 515-530. refs
(SAE PAPER 860968)

The NASA Space Station's three-man Initial Operating Configuration's various conventional Air Revitalization System alternatives are presently compared with a biologically based system, with a view to the practical engineering requirements of this radical alternative. While the proposed biological system does not offer advantages in overall equivalent weight, it establishes the basis for a totally safe system that combines air, water, and waste management functions. The hardware employed includes an algal bioreactor, which may constitute the developmental starting-point for the long-term development of a controlled ecological life support system. O.C.

A87-38752* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LIFE SCIENCES RESEARCH FACILITY AUTOMATION REQUIREMENTS AND CONCEPTS FOR THE SPACE STATION

DARYL N. RASMUSSEN (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 539-552.
(SAE PAPER 860970)

An evaluation is made of the methods and preliminary results of a study on prospects for the automation of the NASA Space Station's Life Sciences Research Facility. In order to remain within current Space Station resource allocations, approximately 85 percent of planned life science experiment tasks must be automated; these tasks encompass specimen care and feeding, cage and instrument cleaning, data acquisition and control, sample analysis, waste management, instrument calibration, materials inventory and management, and janitorial work. Task automation will free crews for specimen manipulation, tissue sampling, data interpretation and communication with ground controllers, and experiment management. O.C.

A87-38753

HABITABILITY ISSUES FOR THE SCIENCE LABORATORY MODULE

GORDON V. FOGLEMAN (General Electric Co., Fairfield, CT), JOHN M. RIGSBY (Grumman Aerospace Corp., Bethpage, NY), and ROBERT L. CURTIS IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 553-559.
(SAE PAPER 860971)

Attention is given to concepts for Space Station Science Laboratory Module control console layout, crew restraints, trash management, and emergency eye washes and showers, in light of experience obtained during the Skylab and Spacelab programs and with a view to the far greater experimental complexity, longer mission duration, and largely civilian (rather than professional astronaut) status of Space Station crews. Work environment color and decoration has been found to have a profound effect on crew moods, attitudes, and productivity. Also essential in view of Skylab and Spacelab experience is crew privacy, which ensures concentration in analytical thought tasks associated with research and/or operations of a critical nature. O.C.

A87-38761* Umpqua Research Co., Myrtle Creek, Ore.

PRE- AND POST-TREATMENT TECHNIQUES FOR SPACECRAFT WATER RECOVERY

DAVID F. PUTNAM, GERALD V. COLOMBO (Umpqua Research Co., Myrtle Creek, OR), and CINDA CHULLEN (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 627-634. refs
(SAE PAPER 860982)

Distillation-based waste water pretreatment and recovered water posttreatment methods are proposed for the NASA Space Station. Laboratory investigation results are reported for two nonoxidizing urine pretreatment formulas (hexadecyl trimethyl ammonium bromide and Cu/Cr) which minimize the generation of volatile organics, thereby significantly reducing posttreatment requirements. Three posttreatment methods (multifiltration, reverse osmosis, and UV-assisted ozone oxidation) have been identified which appear promising for the removal of organic contaminants from recovered water. O.C.

A87-38762* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

RESULTS ON REUSE OF RECLAIMED SHOWER WATER

CHARLES E. VEROSTKO, RAFAEL GARCIA, DUANE L. PIERSON (NASA, Johnson Space Center, Houston, TX), RICHARD P. REYSA (Boeing Aerospace Co., Houston, TX), and ROBERT IRBE (Northrop Services, Inc., Microbiology Dept., Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 635-643. refs
(SAE PAPER 860983)

The Waste Water Recovery System that has been used in conjunction with a microgravity whole body shower to test a closed loop shower water reclamation system applicable to the NASA Space Station employs a Thermoelectric Integrated Hollow Fiber Membrane Evaporation Subsystem. Attention is given to the suitability of a Space Shuttle soap for such crew showers, the effects of shower water on the entire system, and the purification qualities of the recovered water. The chemical pretreatment of the shower water for microorganism control involved activated carbon, mixed ion exchange resin beds, and iodine bactericide dispensing units. The water was recycled five times, demonstrating the feasibility of reuse. O.C.

A87-38763* Bend Research, Inc., Oreg.

A MEMBRANE-BASED SUBSYSTEM FOR VERY HIGH RECOVERIES OF SPACECRAFT WASTE WATERS

RODERICK J. RAY, SANDRA E. RETZLAFF, LYN RADKE-MITCHELL, DAVID D. NEWBOLD (Bend Research, Inc., OR), and DONALD F. PRICE (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 645-659. refs
(SAE PAPER 860984)

This paper describes the continued development of a membrane-based subsystem designed to recover up to 99.5 percent of the water from various spacecraft waste waters. Specifically discussed are: (1) the design and fabrication of an energy-efficient reverse-osmosis (RO) breadboard subsystem; (2) data showing the performance of this subsystem when operated on a synthetic wash-water solution - including the results of a 92-day test; and (3) the results of pasteurization studies, including the design and operation of an in-line pasteurizer. Also included in this paper is a discussion of the design and performance of a second RO stage. This second stage results in higher-purity product water at a minimal energy requirement and provides a substantial redundancy factor to this subsystem. Author

A87-38764* Chamberlain Mfg. Corp., Waterloo, Iowa.

DEVELOPMENT OF A WATER RECOVERY SUBSYSTEM BASED ON VAPOR PHASE CATALYTIC AMMONIA REMOVAL (VPCAR)

P. BUDININKAS, F. RASOULI (Chamberlain Manufacturing, Inc., GARD Div., Niles, IL), and T. WYDEVEN (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 661-667. refs
(Contract NAS2-11687)
(SAE PAPER 860985)

An integrated engineering breadboard subsystem for the recovery of potable water from untreated urine was designed, fabricated and tested. It was fabricated from commercially available components without emphasis on weight, volume and power requirement optimization. Optimizing these parameters would make this process competitive with other spacecraft water recovery systems. Unlike other phase change systems, this process is based on the catalytic oxidation at elevated temperatures of ammonia and volatile hydrocarbons to innocuous products; therefore, no urine pretreatment is required. The testing program consisted of parametric tests, one month of daily tests, and a continuous run of 165 hours. The recovered water is low in ammonia, hydrocarbons and conductivity and requires only adjustment of its pH to meet drinking water standards. Author

A87-38765
PHASE CHANGE WATER RECOVERY FOR SPACE STATION - PARAMETRIC TESTING AND ANALYSIS
ED M. ZDANKIEWICZ and JAMES CHU (Life Systems, Inc., Cleveland, OH) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 669-679.
(SAE PAPER 860986)

A parametric testing and a hardware improvement program have been conducted by NASA for a Vapor Compression Distillation Subsystem (VCDS) applicable to the Space Station for phase change recovery of potable water from waste water. This VCDS was designed to reclaim 95 percent of the available waste water at a nominal water recovery rate of 1.36 kg/hr and 308 K condenser temperature; a 300-percent improvement in water production rate, however, with a correspondingly lower specific energy, was achieved following incorporation of several improvements. O.C.

A87-38766* AiResearch Mfg. Co., Torrance, Calif.
AIR EVAPORATION CLOSED CYCLE WATER RECOVERY TECHNOLOGY - ADVANCED ENERGY SAVING DESIGNS
GWYNDOLYN MORASKO (AiResearch Manufacturing Co., Torrance, CA), DAVID F. PUTNAM (Umpqua Research Co., Myrtle Creek, OR), and ROBERT BAGDIGIAN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 681-690.
(SAE PAPER 860987)

The Air Evaporation water recovery system is a visible candidate for Space Station application. A four-man Air Evaporation open cycle system has been successfully demonstrated for waste water recovery in manned chamber tests. The design improvements described in this paper greatly enhance the system operation and energy efficiency of the air evaporation process. A state-of-the-art wick feed design which results in reduced logistics requirements is presented. In addition, several design concepts that incorporate regenerative features to minimize the energy input to the system are discussed. These include a recuperative heat exchanger, a heat pump for energy transfer to the air heater, and solar collectors for evaporative heat. The addition of the energy recovery devices will result in an energy reduction of more than 80 percent over the systems used in earlier manned chamber tests. Author

A87-38770* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUPERCRITICAL WATER OXIDATION - CONCEPT ANALYSIS FOR EVOLUTIONARY SPACE STATION APPLICATION
JOHN B. HALL, JR. (NASA, Langley Research Center, Hampton, VA) and DANA A. BREWER (Vigyan Research Associates, Inc., Hampton, VA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 733-745. refs
(Contract NAS1-17919)
(SAE PAPER 860993)

The ability of a supercritical water oxidation (SCWO) concept to reduce the number of processes needed in an evolutionary Space Station design's Environmental Control and Life Support System (ECLSS), while reducing resupply requirements and enhancing the integration of separate ECLSS functions into a single Supercritical Water Oxidation process, is evaluated. While not feasible for an initial operational capability Space Station, the SCWO's application to the evolutionary Space Station configuration would aid the integration of eight ECLSS functions into a single one, thereby significantly reducing program costs. O.C.

A87-38771* Life Systems, Inc., Cleveland, Ohio.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT TECHNOLOGIES FOR ADVANCED MANNED SPACE MISSIONS
F. T. POWELL, R. A. WYNVEEN (Life Systems, Inc., Cleveland, OH), and C. LIN (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 747-759. refs
(SAE PAPER 860994)

Regenerative environmental control and life support system (ECLSS) technologies are found by the present evaluation to have reached a degree of maturity that recommends their application to long duration manned missions. The missions for which regenerative ECLSSs are attractive in virtue of the need to avoid expendables and resupply requirements have been identified as that of the long duration LEO Space Station, long duration stays at GEO, a permanently manned lunar base (or colony), manned platforms located at the earth-moon libration points L4 or L5, a Mars mission, deep space exploration, and asteroid exploration. A comparison is made between nonregenerative and regenerative ECLSSs in the cases of 10 essential functions. O.C.

A87-38772* Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.
AN ADVANCED CARBON REACTOR SUBSYSTEM FOR CARBON DIOXIDE REDUCTION
GARY P. NOYES (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and ROBERT J. CUSICK (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 761-768. refs
(SAE PAPER 860995)

An evaluation is presented of the development status of an advanced carbon-reactor subsystem (ACRS) for the production of water and dense, solid carbon from CO2 and hydrogen, as required in physiochemical air revitalization systems for long-duration manned space missions. The ACRS consists of a Sabatier Methanation Reactor (SMR) that reduces CO2 with hydrogen to form methane and water, a gas-liquid separator to remove product water from the methane, and a Carbon Formation Reactor (CFR) to pyrolize methane to carbon and hydrogen; the carbon is recycled to the SMR, while the produce carbon is periodically removed from the CFR. A preprototype ACRS under development for the NASA Space Station is described. O.C.

A87-38773* General Electric Co., Houston, Tex.
INTEGRATED WASTE AND WATER MANAGEMENT SYSTEM
R. W. MURRAY (General Electric Co., Houston, TX) and R. L. SAUER (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 769-774.
(SAE PAPER 860996)

The performance requirements of the NASA Space Station have prompted a reexamination of a previously developed integrated waste and water management system that used distillation and catalytic oxydation to purify waste water, and microbial digestion and incineration for waste solids disposal. This system successfully operated continuously for 206 days, for a 4-man equivalent load of urine, feces, wash water, condensate, and trash. Attention is given to synergisms that could be established with other life support systems, in the cases of thermal integration, design commonality, and novel technologies. O.C.

A87-38774
CELSS WASTE MANAGEMENT SYSTEMS EVALUATION
THOMAS J. SLAVIN, FREDERICK A. LIENING, and MELVIN W. OLESON (Boeing Aerospace Co., Space Systems Div., Seattle, WA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of

Automotive Engineers, Inc., 1986, p. 775-790. refs
(SAE PAPER 860997)

This report compares parametric data for the following six waste management subsystems, as considered for use on the Space Station: (1) dry incineration, (2) wet oxidation, (3) supercritical water oxidation, (4) vapor compression distillation, (5) a thermoelectric integrated membrane evaporation system, and (6) vapor phase catalytic ammonia removal. The parameters selected for comparison are on-orbit weight and volume, resupply and return to earth logistics, power consumption, and heat rejection. The six waste treatment subsystems modeled in this program are sized to process the wastes for a 90-day Space Station mission with a crew of eight persons and an emergency supply period of 28 days. Author

A87-38779
CONTROL/MONITOR INSTRUMENTATION FOR ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS ABOARD THE SPACE STATION
DENNIS B. HEPPNER, JIM M. KHOURY, and JIM D. POWELL (Life Systems, Inc., Cleveland, OH) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 835-844.
(SAE PAPER 861007)

Automatic monitoring and control of the NASA Space Station's subsystems operation in order to free crews for scientific experiments will involve real time data processing, subsystem fault tolerance and redundancy management, caution and warning, health monitoring and trend analysis, data management, and support for on-orbit maintenance and repair. Attention is presently given to the Environmental Control and Life Support System's automation requirements, detailing sensor and actuator requirements and the controller's hierarchy design. The evolutionary development of a family of controllers for autonomous operation at both the prototype and flight production levels is also discussed. O.C.

A87-41066
DYNAMIC BEHAVIOR OF ASTRONAUTS AND SATELLITES OUTSIDE AN ORBITING SPACE STATION UNDER THE INFLUENCE OF THRUST
H. F. BAUER (Muenchen, Universitaet der Bundeswehr, Neubiberg, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 11, Jan.-Feb. 1987, p. 12-18.

The motion trajectories of astronauts during space walks or of satellites when outside a space station under the action of a constant thrust are determined with and without the effect of mass change during the thrusting period. Different magnitudes and directions of thrust application are investigated. Author

A87-43122#
EXTERNAL CONTAMINATION ENVIRONMENT OF SPACE STATION CUSTOMER SERVICING FACILITY
MICHAEL C. FONG, ALECK L. LEE, and PAUL T. MA (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 11 p. refs
(AIAA PAPER 87-1623)

The paper discusses the results of an analytical study to define the on-orbit external contamination environment of the Space Station (SS) Customer Servicing Facility (CSF). The topics included in this paper are: (1) molecular contaminant transport from outgassing sources to the CSF interior and other SS surfaces due to direct or reflected/reevaporated molecular fluxes as well as intermolecular collisions, (2) orbiter reaction control system plume contamination during proximity operations, and (3) particulate contaminant cloud environment of the CSF. Sample predictions are based on a twin-keeled SS configuration with a typical large payload and assumed proximity operational scenarios. The maximum molecular contaminant flux (in terms of incident flux) on the CSF payload could be as high as 1.5 x 10 to the -8th g/sq cm-sec due to direct/reflected/reevaporated fluxes and 10 to the -8th g/sq cm-sec due to molecular backscatter, the most severe source being moisture desorption from astronaut's suit during extravehicular activity. Author

A87-53979* Vigyan Research Associates, Inc., Hampton, Va.
A SIMULATION MODEL FOR THE ANALYSIS OF SPACE STATION GAS-PHASE TRACE CONTAMINANTS
DANA A. BREWER (Vigyan Research Associates, Inc., Hampton, VA) and JOHN B. HALL, JR. (NASA, Langley Research Center, Hampton, VA) Acta Astronautica (ISSN 0094-5765), vol. 15, Aug. 1987, p. 527-543. refs
(Contract NAS1-550; NAS1-17919)

A simulation model for the analysis of gas-phase trace contaminants in the cabin air of the NASA Space Station Reference Configuration was developed at the NASA Langley Research Center. The model predicts changes in trace contaminant concentrations from both physical and chemical sources and sinks as a function of time. Simulations were performed in which values for relative humidity, temperature, radiation intensity, pressure, and initial species concentrations were constrained to values for these parameters measured and modeled in the continental tropics at the earth's surface. Species concentrations simulated using the model compared favorably with concentrations in the continental tropics which demonstrated that the chemical mechanism in the trace contaminant model approximates changes in atmospheric species concentrations. The sensitivity of initial species concentrations to producing changes in additional species concentrations was also assessed. Results from the model indicated that chemical reactions will be important in determining the composition of cabin air in the Space Station. It is anticipated that the trace contaminant model will be useful in assessing the impact of experiments and commercial operations on the composition of the cabin air in the Space Station. Author

N87-21155*# Hamilton Standard, Windsor Locks, Conn.
MAINTENANCE EVALUATION FOR SPACE STATION LIQUID SYSTEMS
CHARLES FLUGEL *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 171-187 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

Many of the thermal and environmental control life support subsystems as well as other subsystems of the space station utilize various liquids and contain components which are either expendables or are life-limited in some way. Since the space station has a 20-year minimum orbital lifetime requirement, there will also be random failures occurring within the various liquid-containing subsystems. These factors as well as the planned space station build-up sequence require that maintenance concepts be developed prior to the design phase. This applies to the equipment which needs maintenance as well as the equipment which may be required at a maintenance work station within the space station. This paper presents several maintenance concepts for liquid-containing items and a flight experiment program which would allow for evaluation and improvement of these concepts so they can be incorporated in the space station designs at the outset of its design phase. Author

N87-24064*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS IN SPACE STATION ARCHITECTURE 2. EVA ACCESS FACILITY: A COMPARATIVE ANALYSIS OF 4 CONCEPTS FOR ON-ORBIT SPACE SUIT SERVICING
MARC M. COHEN and STEVEN BUSSOLARI (Massachusetts Inst. of Tech., Cambridge.) Apr. 1987 25 p
(NASA-TM-86856; A-86037; NAS 1.15:86856) Avail: NTIS HC A02/MF A01 CSCL 05H

Four concepts for on-orbit spacesuit donning, doffing, servicing, check-out, egress and ingress are presented. These are: the Space Transportation System (STS) Type (shuttle system enlarged), the Transit Airlock (Shuttle Airlock with suit servicing removed from the pump-down chamber), the Suitport (a rear-entry suit mates to a port in the airlock wall), and the Crewlock (a small, individual, conformal airlock). Each of these four concepts is compared through a series of seven steps representing a typical Extra Vehicular Activity (EVA) mission: (1) Predonning suit preparation; (2) Portable Life Support System (PLSS) preparation; (3) Suit Donning and Final Check; (4) Egress/Ingress; (5) Mid-EVA rest period; (6) Post-EVA Securing; (7) Non-Routine Maintenance. The different characteristics of each concept are articulated through this step-by-step approach. Recommendations concerning an approach for further evaluations of airlock geometry, anthropometrics, ergonomics, and functional efficiency are made. The key recommendation is that before any particular airlock can be designed, the full range of spacesuit servicing functions must be considered, including timelines that are most supportive of EVA human productivity. Author

N87-26086*# Science and Engineering Associates, Inc., Englewood, Colo.
CONTAMINATION ASSESSMENT FOR OSSA SPACE STATION IOC PAYLOADS Final Report, 6 May - 24 Nov. 1986
S. CHINN, T. GORDON, and R. RANTANEN Aug. 1987 137 p
(Contract NAS8-36102; NAG8-592)
(NASA-CR-4091; NAS 1.26:4091) Avail: NTIS HC A07/MF A01 CSCL 22B

The results are presented from a study for the Space Station Planners Group of the Office of Space Sciences and Applications. The objectives of the study are: (1) the development of contamination protection requirements for protection of Space Station attached payloads, serviced payloads and platforms; and (2) the determination of unknowns or major impacts requiring further assessment. The nature, sources, and quantitative properties of the external contaminants to be encountered on the Station are summarized. The OSSA payload contamination protection requirements provided by the payload program managers are reviewed and the level of contamination awareness among them is discussed. Preparation of revisions to the contamination protection requirements are detailed. The comparative impact of flying the Station at constant atmospheric density rather than constant altitude is assessed. The impact of the transverse boom configuration of the Station on contamination is also assessed. The contamination protection guidelines which OSSA should enforce during their development of payloads are summarized. Author

N87-26703*# Galveston Coll., Tex. Div. of Mathematics and Science.
EXPANSION OF SPACE STATION DIAGNOSTIC CAPABILITY TO INCLUDE SEROLOGICAL IDENTIFICATION OF VIRAL AND BACTERIAL INFECTIONS
KELLY E. HEJTMANCIK *In* NASA. Lyndon B. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1986, Volume 1 22 p Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 05A

It is necessary that an adequate microbiology capability be provided as part of the Health Maintenance Facility (HMF) to support expected microbial disease events during long periods of space flight. The applications of morphological and biochemical studies to confirm the presence of certain bacterial and fungal disease agents are currently available and under consideration. This confirmation would be greatly facilitated through employment of serological methods to aid in the identification for not only bacterial and fungal agents, but viruses as well. A number of serological approached were considered, particularly the use of Enzyme Linked Immunosorbent Assays (ELISAs), which could be utilized during space flight conditions. A solid phase, membrane supported ELISA for the detection of Bordetella pertussis was developed to show a potential model system that would meet the HMF requirements and specifications for the future space station. A second model system for the detection of Legionella pneumophila, an expected bacterial disease agent, is currently under investigation. Author

N87-27392*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
QUALITY REQUIREMENTS FOR RECLAIMED/RECYCLED WATER
DANIEL S. JANIK (National Academy of Sciences - National Research Council, Houston, Tex.), RICHARD L. SAUER, DUANE L. PIERSON, and YVONNE R. THORSTENSON Mar. 1987 35 p
(NASA-TM-58279; S-559; NAS 1.15:58279) Avail: NTIS HC A03/MF A01 CSCL 06K

Water used during current and previous space missions has been either carried or made aloft. Future human space endeavors will require some form of water reclamation and recycling. There is little experience in the U.S. space program with this technology. Water reclamation and recycling constitute engineering challenges of the broadest nature that will require an intensive research and development effort if this technology is to mature in time for practical use on the proposed U.S. Space Station. In order for this to happen, reclaimed/recycled water specifications will need to be devised to guide engineering development. Present NASA Potable Water Specifications are not applicable to reclaimed or recycled water. Adequate specifications for ensuring the quality of the reclaimed or recycled potable water system is reviewed, limitations of present water specifications are examined, world experience with potable water reclamation/recycling systems and systems analogs is reviewed, and an approach to developing pertinent biomedical water specifications for spacecraft is presented. Space Station water specifications should be designed to ensure the health of all likely spacecraft inhabitants including man, animals, and plants. Author

N87-27405*# Texas Univ., Austin. Dept. of Psychology.
THE UNDERSEA HABITAT AS A SPACE STATION ANALOG: EVALUATION OF RESEARCH AND TRAINING POTENTIAL
ROBERT L. HELMREICH and JOHN A. WILHELM 1 Oct. 1985 20 p
(Contract NCC2-286)
(NASA-CR-180342; NAS 1.26:180342) Avail: NTIS HC A02/MF A01 CSCL 05H

An evaluation is given of the utility of undersea habitats for both research and training on behavioral issues relative to the space station. The feasibility of a particular habitat, La Chalupa, is discussed. Author

N87-27407*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SUIT EXTRAVEHICULAR HAZARDS PROTECTION DEVELOPMENT
JOSEPH J. KOSMO 14 Jan. 1987 32 p
(NASA-TM-89355; NAS 1.15:89355) Avail: NTIS HC A03/MF A01 CSCL 06K

Presented is an overview of the development of the integral thermal/micrometeoroid garment (ITMG) used for protection of a space-suited crewmember from hazards of various extravehicular environments. These hazard conditions can range from thermal extremes, meteoroid and debris particles, and radiation conditions in near-earth orbits and free space to sand and dust environments encountered on lunar or planetary surfaces. Representative ITMG materials cross-section layups are identified and described for various space-suit configurations ranging from the Gemini Program to planned protective requirements and considerations for anticipated Space Station EV operations. Author

N87-29117*# Honeywell, Inc., Clearwater, Fla. Space and Strategic Avionics Div.
AUTOMATED SUBSYSTEM CONTROL FOR LIFE SUPPORT SYSTEM (ASCLSS) Final Report
ROGER F. BLOCK 15 Jul. 1987 65 p
(Contract NAS9-16895)
(NASA-CR-172003; NAS 1.26:172003) Avail: NTIS HC A04/MF A01 CSCL 06K

The Automated Subsystem Control for Life Support Systems (ASCLSS) program has successfully developed and demonstrated a generic approach to the automation and control of space station subsystems. The automation system features a hierarchical and distributed real-time control architecture which places maximum controls authority at the lowest or process control level which enhances system autonomy. The ASCLSS demonstration system pioneered many automation and control concepts currently being considered in the space station data management system (DMS). Heavy emphasis is placed on controls hardware and software commonality implemented in accepted standards. The approach demonstrates successfully the application of real-time process and accountability with the subsystem or process developer. The ASCLSS system completely automates a space station subsystem (air revitalization group of the ASCLSS) which moves the crew/operator into a role of supervisory control authority. The ASCLSS program developed over 50 lessons learned which will aide future space station developers in the area of automation and controls.. Author

N87-29594*# Boeing Aerospace Co., Kent, Wash. Flight Technology Group.
SPACE STATION PROPULSION-ECLSS INTERACTION STUDY Final Report
SCOTT M. BRENNAN 14 Feb. 1986 92 p
(Contract NAS3-23353)
(NASA-CR-175093; NAS 1.26:175093; D483-10060-1) Avail: NTIS HC A05/MF A01 CSCL 21H

The benefits of the utilization of effluents of the Space Station Environmental Control and Life Support (ECLS) system are examined. Various ECLSS-propulsion system interaction options are evaluated and compared on the basis of weight, volume, and power requirements. Annual propulsive impulse to maintain station altitude during a complete solar cycle of eleven years and the effect on station resupply are considered. Author

06

DYNAMICS AND CONTROLS

Includes descriptions of analytical techniques and computer codes, trade studies, requirements and descriptions of orbit maintenance systems, rigid and flexible body attitude sensing systems and controls such as momentum wheels and/or propulsive schemes.

A87-31681* Rice Univ., Houston, Tex.
OPTIMAL TRAJECTORIES FOR AEROASSISTED, COPLANAR ORBITAL TRANSFER
A. MIELE (Rice University, Houston, TX), V. K. BASAPUR, and W. Y. LEE Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 52, Jan. 1987, p. 1-24. refs
(Contract JPL-956415)

Classical and minimax optimal control problems arising in the study of aeroassisted coplanar orbit transfer from a high planetary orbit to a low one are considered. Attention is given to (1) the minimization of the energy required for the maneuver; (2) minimization of the time integral of the heating rate; (3) minimization of the time of flight during the atmospheric portion of the trajectory; (4) maximization of the time of flight during the atmospheric portion of the trajectory; (5) minimization of the time integral of the path inclination; and (6) minimization of the sum of the squares of the entry and exit path inclinations. O.C.

A87-32117
CONTROL OPERATIONS IN ADVANCED AEROSPACE SYSTEMS
WILLIAM R. GRAHAM (R&D Associates, Marina Del Rey, CA) (IFAC, Symposium on Control of Distributed Parameter Systems, Los Angeles, CA, June 30-July 2, 1986) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Feb. 1987, p. 3-8.

Distributed parameter control systems being studied by NASA for use in advanced aerospace systems are described. A 15 m diam antenna that will be deployed in space from a 2 cu m box has 96 control cables for controlling the shape of the antenna. Appropriate near- and far-field tests are needed for tuning the shape of the antenna on-orbit. The Space Station will be dynamically stabilized, damped and pointed with a high degree of accuracy, performed to a high degree by automated systems that adapt to a growing structure. Self-diagnosis is also a necessary feature of future EVA equipment and telerobotics, the latter assuming greater importance in a Rover for exploring the surface of Mars. The concepts are being implemented in the X-29 forward swept wing aircraft, the electronics of the Hubble Space Telescope, and in studies of the national aerospaceplane. M.S.K.

A87-32338
TRANSIENT DYNAMICS OF ORBITING FLEXIBLE STRUCTURAL MEMPERS
V. J. MODI and A. M. IBRAHIM (British Columbia, University, Vancouver, Canada) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 483-488.
(Contract NSERC-67-1547)

Using a relatively general formulation procedure, this paper reviews complex interactions between deployment, attitude dynamics, and flexural rigidity for configurations representing deployment of beam and tether type appendages. The results suggest substantial influence of the flexibility, deployment velocity, initial conditions, and appendage orientation on the response, and under critical combinations of parameters the system can become unstable. The information has relevance to the design of control systems for: (1) the next generation of communication satellites; (2) the Orbiter based experiments such as SAFE (Solar Array Flight Experiment), SCOLE (Structural COntrol Laboratory Experiment), STEP (Structural Technology Exeriment Program), and the NASA/CNR tethered subsatellite system; as well as (3) the evolutionary transient and postconstruction operational phases of the proposed Space Station. Author

A87-32440
LOCAL CONTROL FOR LARGE SPACE STRUCTURES
TAKASHI KIDA, ISAO YAMAGUCHI, and YOSHIAKI OHKAMI (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1231-1236. refs

This paper describes the decentralized local control of a class of large space structures consisting of multirigid bodies that are connected through hinges. The formulation and the controller design are performed for each subbody independently from other contiguous bodies. For a simple two-body system, connective stability bounds are obtained when the local controller is designed by the pole placement method and by cost optimization. Author

A87-32441
A CONSIDERATION TO VIBRATION CONTROL FOR A LARGE SPACE STRUCTURES
ETSUJIRO SHIMEMURA (Waseda University, Tokyo, Japan), TERUO FUJIWARA, TADASHI ADACHI, HIDEHIKO TAMAOKI, and SHINTARO KAWAGUCHI (Nissan Motor Co., Ltd., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1237-1241.

The control problem of flexible space structures is one of the key technologies for the Space Station. This paper presents one approach to damp the vibration of the flexible structure using active control. The selection of the control method, modeling of the structure, and the control law are discussed. Computer simulation is performed to investigate the effects of control parameters. Numerical results show the improvement of the damping of the system and existence of the optimal point in control parameters. Author

A87-32444

VIBRATION CONTROL FOR A LINKED SYSTEM OF FLEXIBLE STRUCTURES

TOSHIO FUKUDA (Tokyo University of Science, Japan) and MASAHIRO ISOGAI IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1255-1260. refs

A vibration control is proposed for a linked flexible system by allocating actuators at the joint of the linkage between the adjacent flexible structure and controlling these actuators, so that the coupled vibrations should be decreased. In order to derive the dynamics of such a linked system, first a flexible structure with the rigid bodies at each end is modeled by the bending vibration equation. Then, a decoupled control is shown based on these dynamics. In the experiments simulating the two-dimensional space environment, each joint at which flexible structures are supported is floated by air, so that there is no friction force from the ground to the floating joint and vice versa. Some experimental results are shown to demonstrate the effect of the proposed method. Author

A87-32446

PRECISE POINTING CONTROL OF FLEXIBLE SPACECRAFT

TOGHIO KASHIWASE, MASAO INOUE, KATSUHIKO YAMADA, and KAZUO TSUCHIYA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1267-1272.

A control system for the antenna pointing and the attitude control of the main body of a flexible communication satellite is proposed. The designing of the controller is described. The performance of the developed controller is evaluated experimentally. The experimental results are compared with numerical simulations of closed loop performances. Good correlation between the experimental and theoretical data is observed. I.F.

A87-32447

A PRELIMINARY STUDY ON A LINEAR INERTIAL ACTUATOR FOR LSS CONTROL

TAKASHI KIDA, ISAO YAMAGUCHI, OSAMU OKAMOTO, YOSHIAKI OHKAMI (National Aerospace Laboratory, Chofu, Japan), YOSHIHARU SHIMAMOTO (Toshiba Corp., Research and Development Center, Kawasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1273-1278.

This paper describes some characteristics of a laboratory model of a linear inertial actuator developed for large space structure damping augmentation. The actuator has the capability of performing direct velocity feedback control to a class of large space structures, without causing control/observation spillover. A fundamental hardware experiment has been performed to demonstrate its capability and to clarify some basic aspects relating to hardware modeling. Author

A87-32448

CONTROL OF FLEXIBLE SOLAR ARRAYS WITH CONSIDERATION OF THE ACTUATOR DYNAMICS OF THE REACTION WHEEL

TOSHIO FUKUDA, HIDEMI HOSOGAI (Tokyo University of Science, Japan), and NOBUYUKI YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1279-1284. refs

This paper describes a control method to suppress such coupled vibrations and other interfering effects between a flexible solar array and a reaction wheel employed as an actuator. Based on the modal control, the dynamics of the overall system are obtained by taking into account the dynamics of the flexible array and the dynamics of the reaction wheel. The vibration measurement is carried out by employing the differential solar cells, which can measure the deflection angles, and the vibrational modes can be estimated. The control performance is evaluated by the sums of the squares of both the actuator consumption energy and the strain gauge output. The settling time of the system is dependent on the size of the reaction wheel employed here. Author

A87-32726

GUIDANCE AND CONTROL 1986; PROCEEDINGS OF THE ANNUAL ROCKY MOUNTAIN GUIDANCE AND CONTROL CONFERENCE, KEYSTONE, CO, FEB. 1-5, 1986

ROBERT D. CULP, ED. (Colorado, University, Boulder) and JOHN C. DURRETT, ED. (Martin Marietta Corp., Denver, CO) Conference sponsored by AAS. San Diego, CA, Univelt, Inc. , 1986, 459 p. For individual items see A87-32727 to A87-32751.

The development state of the art, and future designs of guidance and control systems for space applications are explored. The discussions cover control and pointing systems for large space structures such as the Space Station, passive damping and isolation techniques, and active vibration control for a Shuttle-based dynamic structural laboratory. Recent advances in control theory and in sensor, actuator and computational hardware and sophisticated guidance and control systems installed on the Galileo, Gamma Ray Observatory, Cosmic Background Explorer and Multi-Mission Modular Spacecraft are described. Conceptual designs and analyses being performed to support development of the Transfer Orbit Stage and the Orbital Maneuvering Vehicle are summarized, as are design features and test data from the SPACELAB Instrument Pointing System, the Solar Array Flight Dynamic Experiment, and Giotto guidance systems. Also, control systems and design features of telerobotic systems being studied as adjuncts to Shuttle and Space Station crew operations are discussed. M.S.K.

A87-32727* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SYSTEM LEVEL VERIFICATION APPLYING THE SPACE SHUTTLE EXPERIENCE TO THE SPACE STATION

DAVID W. GILBERT (NASA, Johnson Space Center, Houston, TX) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 3-10.
(AAS PAPER 86-001)

The applicability of the verification process for the Shuttle guidance, navigation and control (GNC) and data management system (DMS) for the development of the Space Station are described. Shuttle avionics hardware/software integration was delayed to finalize the hardware design before detailed definition and testing of the software. A block diagram is provided of the flight simulation laboratory used to test the GNC programs before flight data were available. The Station will have distributed computers, unlike the Orbiter, and will only be assembled fully in space. Standardized integration simulation test equipment are being defined to guide the development of hardware and software. The simulation capability may become part of nominal in-flight operations to initiate new capabilities as they are added to the Station. The Station GNC and DMS systems development will be somewhat simplified relative to those of the Shuttle because ascent and reentry will not be considered for the Station. M.S.K.

A87-32730

LOW-AUTHORITY CONTROL THROUGH PASSIVE DAMPING

RUSSELL N. GEHLING (Martin Marietta Corp., Denver, CO) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 51-69. refs
(Contract F33615-82-C-3222)
(AAS PAPER 86-004)

Results are presented from a study of active and passive damping application to the Representative System Article (RSA) developed under the Passive and Active Control of Space Structures (PACOSS) program of Martin Marietta. Three control

approaches are presented and demonstrated on a truncated model of the RSA. The approaches are active control alone via modal space control, passive damping alone, and low authority passive-active control. Results demonstrate that passive damping reduces the requirements for an active control system in terms of the number of control system components and the complexity of the control algorithm. This leads to simpler, more robust control systems which are likely to be more reliable and less expensive.
Author

A87-32732* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THE SOFTMOUNTED INERTIALLY REACTING POINTING SYSTEM (SIRPNT)

SAMUEL W. SIRLIN and ROBERT A. LASKIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 85-105. refs
(AAS PAPER 86-007)

A softmounted inertially reacting pointing system differs from traditional gimbal-based pointing system architecture in that: (1) the primary pointing control actuator does not need to apply torques on the basebody, and hence will not interact in a destabilizing way with basebody flexibility, and (2) the connection of the payload with the basebody is via a soft, low frequency structure, which acts as a two-way low pass filter for disturbances. Planar, linear analysis of a preliminary design of such a pointing system using the piezoelectric polymer material PVF2 as an active element in the softmount is presented demonstrating the potential performance in disturbance rich environments such as Space Station.
Author

A87-32736* Fairchild Space and Electronics Co., Germantown, Md.

SPACE INFRARED TELESCOPE FACILITY/MULTIMISSION MODULAR SPACECRAFT ATTITUDE CONTROL SYSTEM CONCEPTUAL DESIGN

BRIAN F. CLASS, RAYMOND V. WELCH (Fairchild Space Co., Germantown, MD), FRANK H. BAUER (NASA, Goddard Space Flight Center, Greenbelt, MD), and KIM STROHBEHN (Johns Hopkins University, Laurel, MD) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 155-175. refs
(AAS PAPER 86-031)

A control system utilizing the Multi-mission Modular Spacecraft (MMS) Attitude Control System (ACS) was developed and analyzed for the Space Infrared Telescope Facility (SIRTF) spacecraft. Alternative torquer augmentation schemes were studied to determine viable ACS approaches. A control law was developed to use a dual set of single-axis Control Moment Gyros (CMGs) for two-axis control. Flexible structural models were developed using a high fidelity, flight tested NASTRAN model of the MMS, coupled with a NASTRAN model of the SIRTF telescope. Model significance criteria were employed to reduce the structural model. Multivariable interactive techniques were used to synthesize the control system (including the structural filters). Control system performance for the SIRTF operational modes (quiescent inertial hold, slewing, nodding, and rastering) was then determined using both single-axis and three-axis simulations). The control system described met performance requirements for all modes but the raster with the use of CMGs. The raster performance was limited by the structural flexibility.
Author

A87-32741

A HIGHLY ADAPTABLE STEERING/SELECTION PROCEDURE FOR COMBINED CMG/RCS SPACECRAFT CONTROL

JOSEPH A. PARADISO (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 263-282. Research supported by Charles Stark Draper Laboratory, Inc. refs
(AAS PAPER 86-036)

Attitude control laws are presented which will permit coordinated operation of control moment gyroscopes (CMG) and reaction control systems (RCS) on the Space Station. Emphasis was placed on defining a flexible CMG steering algorithm. Control laws are defined for obtaining a set of gimbal rates to match the CMG torque to a specific value in coordination with RCS jet firing. A linear programming algorithm is provided for generating optimized decision variables for the CMG/RCS actuators to meet a desired vehicle rate of change. Penalty functions are formulated to guide the selection of actuator commands. RCS firing, to be limited to an impulse mode, will be restricted to conditions requiring translational motion and when the CMG cannot respond due to saturation. Results are provided from simulations of attitude control for the Space Station power tower concept.
M.S.K.

A87-33573*# California Univ., Los Angeles.

CONTROL AUGMENTED STRUCTURAL SYNTHESIS WITH TRANSIENT RESPONSE CONSTRAINTS

R. A. MANNING and L. A. SCHMIT (California University, Los Angeles) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 194-204. Research supported by General Motors Corp. refs
(Contract NSG-1490)
(AIAA PAPER 87-0749)

An integrated approach to the optimum design of control augmented structural systems is presented in which structural variables and control variables are changed simultaneously during the design process. Constraints are imposed on peak transient dynamic displacements and accelerations, static displacements, natural frequencies, and control system effort. Side constraints imposed on structural member sizes and control system thresholds and actuator output forces insure the generation of physically meaningful designs. Example problems are presented which bring out the benefits of simultaneous treatment of both the structural design variables and the control design variables.
Author

A87-33710#

SENSITIVITY OF DISTRIBUTED STRUCTURES TO MODEL ORDER IN FEEDBACK CONTROL

LEONARD MEIROVITCH and MARK A. NORRIS (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 578-587. refs
(Contract AF-AFOSR-83-0017)
(AIAA PAPER 87-0900)

Feedback controls generated on the basis of a discretized model are applied to the actual distributed system, and the corresponding closed-loop poles are obtained. The sensitivity of the distributed system to feedback controls is studied by examining the incremental change in the closed-loop poles corresponding to a reduction in the order of the discretized model. In the second form of the sensitivity study, closed-loop poles are plotted as the order of the discretized model varies. From a numerical model it is shown that feedback controls designed on the basis of low-order discretized models induce instability in the actual distributed structure.
R.R.

A87-33713*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

A COMPARISON OF ACTIVE VIBRATION CONTROL TECHNIQUES - OUTPUT FEEDBACK VS OPTIMAL CONTROL

ZORAN N. MARTINOVIC, RAPHAEL T. HAFTKA, WILLIAM L. HALLAUER, JR., and GEORGE C. SCHAMEL, II (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th,

Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 610-621. refs
(Contract NAG1-224)
(AIAA PAPER 87-0904)

The paper presents analytical and experimental comparison of two control laws for a laboratory structure designed to simulate large space structures. The first control law is the standard linear quadratic law, which is optimal but requires model reduction for practical implementation. The second control law is a new simple direct feedback control law designed to minimize control forces while guaranteeing stability. The optimal control law was found to be only slightly better than the direct feedback law even in terms of the quadratic performance index. Moreover, the optimal control law provided almost no margin of stability for the unmodeled modes while the direct feedback law provided significant stability margins to all modes. The above results were verified experimentally using a digital implementation of the control laws. Excellent agreement between the analytical prediction and experimental measurements was observed. Author

A87-33714*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ACCURACY OF DERIVATIVES OF CONTROL PERFORMANCE USING A REDUCED STRUCTURAL MODEL
CHRIS A. SANDRIDGE and RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 622-628. refs
(Contract NAG1-603)
(AIAA PAPER 87-0905)

The sensitivity of control system performance to structural changes is calculated for a multi-span beam with direct-rate feedback vibration control. Reduced models based on the natural modes of the structure are formed and derivatives of the damping ratios of the closed-loop eigenvalues are calculated. The convergence of the derivatives of the damping ratios with increasing number of modes is shown to be slower than the convergence of the damping ratios themselves. In particular, in some cases the convergence of finite-element approximations to the derivatives is much faster than the convergence of the modal approximations. The results indicate that the use of reduced models based on natural vibration modes may be ill-advised for calculating the sensitivity of control system performance to changes in the controlled structure. Author

A87-33730#
HIGH SPEED SIMULATION OF MULTI-FLEXIBLE-BODY SYSTEMS WITH LARGE ROTATIONS
R. E. JONES, T. W. MORSE, and W. C. RUSSELL (Boeing Aerospace Co., Seattle, WA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 781-789. refs
(AIAA PAPER 87-0930)

The paper describes a fast multi-flexible-body dynamics code that combines nonlinear rigid and linearized flexible mode formulations and is applicable to systems with moderate rotation rates and flexibilities. Large angular motions are handled by updating the flexible modes and restarting the integration of the equations of motion. Comparisons of numerical results and computation times with those of the DISCOS code are given. Author

A87-33731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC AND ATTITUDE CONTROL CHARACTERISTICS OF AN INTERNATIONAL SPACE STATION
THOMAS R. SUTTER, PAUL A. COOPER, JOHN W. YOUNG (NASA, Langley Research Center, Hampton, VA), and DON K. MCCUTCHEN (NASA, Johnson Space Center, Houston, TX) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 790-799.
(AIAA PAPER 87-0931)

The structural dynamic characteristics of the International Space Station (ISS), the interim reference configuration established for NASA's Space Station developmental program, are discussed, and a finite element model is described. Modes and frequencies of the station below 2.0 Hz are derived, and the dynamic response of the station is simulated for an external impulse load corresponding to a failed shuttle-docking maneuver. A three-axis attitude control system regulates the ISS orientation, with control moment gyros responding to attitude and attitude rate signals. No instabilities were found in the attitude control system. R.R.

A87-33738#
ADAPTIVE TRACKING OF DYNAMICAL MODEL BY UNCERTAIN NONLINEARIZABLE SPACECRAFT
J. M. SKOWRONSKI (Queensland, University, Brisbane, Australia) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 861-867. refs
(AIAA PAPER 87-0940)

Model reference adaptive control (MRAC) extended to cover the nonlinearizable systems with several equilibria, is used to control a mechanical space structure. The structure is modelled in general terms as a hybrid system, i.e., assembly of rigid bodies and flexible appendages, with only estimated data on its own configuration. The structure should track in real, possibly stipulated time and with stipulated accuracy a rigid body model with a desired state space behavior. Closed form algorithms for the signal adaptive feedback controllers and adaptive laws are designed together with state predictors which provide the feedback information without having to solve the motion equations. All the above makes the on-board computer to work as a calculator. The technique used bases on Liapunov Design, but the Liapunov functions are well defined and used as intermediate steps only, without appearing in the result. Author

A87-36762
INTELLIGENT FLYWHEEL ENERGY STORAGE UNITS WITH ADDITIONAL FUNCTIONS FOR FUTURE SPACE STATIONS IN NEAR-EARTH ORBITS [INTELLIGENTE SCHWUNGRADENERGIESPEICHER MIT ZUSAETZLICHEN FUNKTIONEN FUER ZUKUENFTIGE RAUMSTATIONEN IN ERDNAHEN UMLAUFBAHNEN]
U. BICHLER (Teldix GmbH, Heidelberg, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 89-97. In German. BMFT-supported research. refs
(DGLR PAPER 86-172)

An intelligent flywheel energy storage system is described which, in addition to providing energy to a space station during solar eclipses, performs additional vital functions. It can act as a correcting element for triaxial positioning and stabilization, as a voltage generator for the on-board electrical network, and as damper of structural vibrations in the station. The flywheel energy storage principle is explained, and the flywheel itself is described. The energy storage, the converter between mechanical and electrical energy, and the performance characteristics of the flywheel are addressed. C.D.

A87-37295* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SHUTTLE ORBIT FLIGHT CONTROL DESIGN LESSONS - DIRECTION FOR SPACE STATION

KENNETH J. COX (NASA, Johnson Space Center, Houston, TX) and PHILIP D. HATTIS (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 336-355. refs
(Contract NAS9-17560)

The Space Shuttle orbit flight control system, which operates during all exo-atmospheric flight phases, has successfully met operational requirements. Many design integration and operational issues that required resolution during development and testing provide an experience base that will benefit the development of future space systems, particularly the Space Station. To this end, the applicable Shuttle and Space Station hardware/software is reviewed with some perspective provided on how current design groundrules were derived and how issues that affected the Shuttle orbit control system design are a pathway for the Space Station. Some of the most significant lessons learned from the Shuttle are summarized, with a discussion of the effect of performance and design of hardware, including the data processing system on software structures and usage procedures. Crew interface issues and important results from man-in-the-loop tests are summarized. Problems resulting from trying to meet difficult orbital operational objectives, including some sophisticated payload operations are characterized. Several proposed Shuttle flight control design improvements, developed in response to some of the lessons learned so far, are identified. Potential application of the Shuttle design lessons and new control technologies to the Space Station are discussed.
Author

A87-39644#

THE DESIGN AND ANALYSIS OF PASSIVE DAMPING FOR AEROSPACE SYSTEMS

DERRICK W. JOHNSON, ROY IKEGAMI (Boeing Aerospace Co., Seattle, WA), and ERIC M. AUSTIN (CSA Engineering, Inc., Palo Alto, CA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987. 11 p.
(Contract F33615-82-C-3226)
(AIAA PAPER 87-0891)

A study has been performed to investigate the use of viscoelastic passive damping technology to decrease the vibroacoustic response of avionics equipment in typical satellite systems. The Boeing Inertial Upper Stage (IUS) was selected as a baseline satellite system to demonstrate these techniques on an established aerospace vehicle with the associated design requirements. To serve as a developmental test bed for evaluation of various damping concepts and validation of the analytical design tools, a smaller component test article, representative of the IUS equipment support section, was fabricated. Using the experience gained from the component test article, damping treatments were designed for the IUS dynamic test vehicle using finite element modeling and the modal strain energy method. These treatments were then installed on the dynamic test vehicle and evaluated through acoustic noise testing. The results of this testing are given compared to previous undamped test results and preestablished goals. Discussions are included about the basis of the goals on system reliability and the impact of the damping treatments on system requirements.
Author

A87-39950*

VARIABLE STRUCTURE CONTROLLER DESIGN FOR SPACECRAFT NUTATION DAMPING

HEBERTT SIRA-RAMIREZ and THOMAS A. W. DWYER, III (Illinois, University, Urbana) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-32, May 1987, p. 435-438. refs
(Contract NAG1-436; NSF ECS-85-16445; N00014-84-C-0149)

Variable structure systems theory is used to design an automatic controller for active nutation damping in momentum biased stabilized spacecraft. Robust feedback stabilization of roll and yaw angular dynamics is achieved with prescribed qualitative characteristics which are totally independent of the spacecraft defining parameters.
Author

A87-40074#

DEPLOYMENT DYNAMICS OF SPACE STRUCTURES

V. J. MODI (British Columbia, University, Vancouver, Canada) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 403-413. refs
(Contract NSERC-67-1547)

Computational techniques for analyzing the deployment of complex flexible space structures are described and demonstrated. The general formulation of Modi and Ibrahim (1984) is extended to account for membrane, shell, and tether appendages with viscous/structural damping and momentum/reaction wheels. The basic principles of this approach are explained, and results for three sample problems (local-vertical deployment of a beam, arbitrary-orientation deployment of a beam from the Shuttle Orbiter, and Shuttle deployment of a subsatellite on a 100-km tether) are presented graphically. The importance of deployment-dynamics analysis tools and data bases for the Space Station is indicated.
T.K.

A87-40867#

DYNAMICS OF A MULTIBODY SYSTEM WITH RELATIVE TRANSLATION ON CURVED, FLEXIBLE TRACKS

DECHANG LI (East China Institute of Technology, Nanjing, People's Republic of China) and PETER W. LIKINS (Lehigh University, Bethlehem, PA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 299-306. refs

Previous generic formulations of equations of motion for multibody systems treat explicitly only special cases of interbody translation, such as unconstrained translation or translation constrained to a straight, rigid track or a rigid plane. But real, physical tracks are not always even nominally straight, and they are always somewhat flexible. In this paper, the previous formulations are extended to accommodate interbody translations that can be characterized nominally by a single scalar variable (such as distance traveled on a curved track or screw path) plus motions induced by small deformations of the track or guideway.
Author

A87-40869#

NEW TIME-DOMAIN IDENTIFICATION TECHNIQUE

FANG-BO YEH and CIANN-DONG YANG (National Chen Kung University, Taiwan, Republic of China) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 313-316.

The novel methodology presented for the identification of vibrating structure model parameters obtains mass, stiffness, and damping matrices corresponding to a lumped equivalent model of the tested structure directly from the impulse response data. The scheme requires only a simple manipulation of the impulse response data. A spring mass-damper system shows the high accuracy of the identification procedure even under conditions in which the number of sampling points is limited.
O.C.

A87-41103*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RESISTOJET CONTROL AND POWER FOR HIGH FREQUENCY AC BUSES

ROBERT P. GRUBER (NASA, Lewis Research Center, Cleveland, OH) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 34 p. Previously announced in STAR as N87-20477. refs
(AIAA PAPER 87-0994)

Resistojets are operational on many geosynchronous communication satellites which all use dc power buses. Multipropellant resistojets were selected for the Initial Operating Capability (IOC) Space Station which will supply 208 V, 20 kHz power. This paper discusses resistojet heater temperature controllers and passive power regulation methods for ac power systems. A simple passive power regulation method suitable for use with regulated sinusoidal or square wave power was designed and tested using the Space Station multipropellant resistojet. The breadboard delivered 20 kHz power to the resistojet heater. Cold start surge current limiting, a power efficiency of 95 percent, and power regulation of better than 2 percent were demonstrated with a two component, 300 W breadboard power controller having a mass of 0.6 kg. Author

A87-41817

ATTITUDE CONTROL OF A SPACECRAFT USING AN EXTENDED SELF-ORGANIZING FUZZY LOGIC CONTROLLER

S. DALEY (Brunel University, Uxbridge, England) and K. F. GILL (Leeds University, England) Institution of Mechanical Engineers, Proceedings, Part C - Mechanical Engineering Science (ISSN 0263-7154), vol. 201, no. C2, 1987, p. 97-106. refs

A simple method for extending the range of sensitivity of the self-organizing fuzzy logic controller (SOC) is proposed. The performance of the resulting controller is studied through its application to the attitude control of a flexible satellite. It is found that the extended SOC can provide excellent control and also possess a high degree of robustness. Author

A87-42505#

RESPONSE BOUNDS FOR LINEAR UNDERDAMPED SYSTEMS

K. H. YAE and D. J. INMAN (New York, State University, Buffalo) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 54, June 1987, p. 419-423. refs
(Contract NSF MEA-83-51807; AF-AFOSR-82-0242; AF-AFOSR-85-0220)
(ASME PAPER 87-APM-34)

This paper examines simple bounds on the displacement response of linear oscillatory multiple degree of freedom systems. Both the free and steady state forced responses are considered. The effect of mode coupling due to viscous damping is examined. The bounds are derived and stated in terms of the physical parameters of the structure and its inputs. Simple examples are given to illustrate the bounds and to compare the bounds developed here with previously published results. Author

A87-42855* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

OPTICAL CORRELATOR USE AT JOHNSON SPACE CENTER

RICHARD D. JUDAY (NASA, Johnson Space Center, Houston, TX) IN: Hybrid image processing; Proceedings of the Meeting, Orlando, FL, Apr. 1, 2, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 22-24.

For automation and robotics in the Space Station era, NASA's Johnson Space Center is pursuing several means of synthetic vision. The optical correlator is one such means. The deformable mirror device will form the basis of the first correlator in this project. In-house and contracted effort is being used. Initial in-house activities will concentrate on an impulse deconvolution technique and on a programmable retina for spatial remappings of an image prior to correlation. The retina will permit a form of edge extraction and other primitive operations. Additionally, it will be used as a research tool for assisting persons with low vision. Author

A87-42816* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ACTUATORS FOR ACTIVELY CONTROLLED SPACE STRUCTURES

P. STUDER, R. SHARMA (NASA, Goddard Space Flight Center, Greenbelt, MD), and A. BAZ (Catholic University of America, Washington, DC) IN: Acquisition, tracking, and pointing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 148-159. refs

A free-flying platform of about 4 x 17 m overall dimensions, carrying a variety of imaging and sounding payloads, calls for an intelligent structure with active dynamic control of structural resonances. The actuators for such a structure must be lightweight, require low power, and allow integration into the structure without degradation of its integrity; the dc-to-100 Hz dynamic range required may entail several types of actuators, as is presently emphasized. Broadband damping of higher-order modes requires modeling of the structure with a distributed array of sensors and actuators. O.C.

A87-42817* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SOFT MOUNTED MOMENTUM COMPENSATED POINTING SYSTEM FOR THE SPACE SHUTTLE ORBITER

SAMUEL W. SIRLIN and CHARLES E. BELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Acquisition, tracking, and pointing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 160-173. DOD-sponsored research.

This paper describes a potential pointing and tracking system for the Space Shuttle with possible future application to Space Station. In order to accomplish high precision pointing and tracking (at rates up to 2 deg/s) in the expected disturbance environment, a high bandwidth gimbaled pointing system is required. A soft-mounted, momentum-compensated gimbal system is suggested for this role. A momentum-compensated system is inertially reacting, decoupling the control system dynamics from the basebody structural dynamics. This allows a soft isolation stage to be added between the basebody and the articulation stage, which attenuates high frequency disturbances. In this paper, three configurations are examined: a hard-mounted system, a passive soft-mounted system, and an active soft-mounted system. Analysis demonstrates that the soft-mounted systems have superior disturbance-rejection properties. The active soft mount allows reduction of the isolation stiffness to zero, and so obtains the highest level of performance. Author

A87-45301* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

FLEXIBLE SYSTEM MODEL REDUCTION AND CONTROL SYSTEM DESIGN BASED UPON ACTUATOR AND SENSOR INFLUENCE FUNCTIONS

YEUNG YAM (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), TIMOTHY L. JOHNSON (General Electric Co., Schenectady, NY), and JEFFREY H. LANG (MIT, Cambridge, MA) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-32, July 1987, p. 573-582. Sponsorship: Research supported by the Lockheed Missiles—and Space Co. refs
(Contract DAAG29-78-C-0020; AF-AFOSR-83-0318)

A model reduction technique based on aggregation with respect to sensor and actuator influence functions rather than modes is presented for large systems of coupled second-order differential equations. Perturbation expressions which can predict the effects of spillover on both the reduced-order plant model and the neglected plant model are derived. For the special case of collocated actuators and sensors, these expressions lead to the derivation of constraints on the controller gains that are, given the validity of the perturbation technique, sufficient to guarantee the stability of the closed-loop system. A case study demonstrates the derivation of stabilizing controllers based on the present technique. The use of control and observation synthesis in modifying the dimension of the reduced-order plant model is also discussed. A numerical example is provided for illustration. Author

A87-47810#

ROBUST MULTIVARIABLE CONTROL OF LARGE SPACE STRUCTURES USING POSITIVITY

G. L. SLATER (Cincinnati, University, OH) and M. D. MCLAREN Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, July-Aug. 1987, p. 393-400. Previously cited in issue 23, p. 3428, Accession no. A86-47925. refs

A87-47811#

DYNAMICS OF GYROELASTIC SPACECRAFT

G. M. T. D'ELEUTERIO and P. C. HUGHES (Toronto, University,

Downsview, Canada) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Technical Papers. Part 2, p. 384-390) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, July-Aug. 1987, p. 401-405. Previously cited in issue 13, p. 1941, Accession no. A85-30365. refs
(Contract NSERC-A-4183)

A87-48273* Nevada Univ., Las Vegas.
ROBUST NONLINEAR ATTITUDE CONTROL OF FLEXIBLE SPACECRAFT
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, May 1987, p. 380-387. refs
(Contract NAS1-17369)

This paper presents an approach to large-angle rotational maneuvers of a spacecraft-beam-tip body configuration based on nonlinear invertibility and linear feedback stabilization. A control law u sub d is derived for the decoupled control of attitude angles, lateral elastic deflections, slopes due to bending and angular deflection due to torsion at the tip of the beam using torquers and force actuators. For the stabilization of the elastic modes, a linear feedback control law u sub s is obtained based on a linearized model augmented with a servocompensator. Simulation results are presented to show that large slewing and elastic mode stabilization can be accomplished. Author

A87-50033
MODELING AND CONTROL OF TORSIONAL VIBRATIONS IN A FLEXIBLE STRUCTURE
TOSHIO FUKUDA, HIDEMI HOSOGAI (Tokyo, Science University, Japan), FUMIHITO ARAI, and NOBUYUKI YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) JSME International Journal (ISSN 0913-185X), vol. 30, June 1987, p. 976-981. refs

This paper describes a modeling method of torsional vibrations of flexible large space structures, such as solar battery arrays, and a control method based on this model. The torsional vibrations are modeled by taking into account the flexibility of the solar array and the inertial moments of the supporting rigid body, based on the unconstrained mode method. Employing this model of the flexible structure, the system and the observation equations of the dynamics can be derived in the form of a state representation after an n mode decomposition. The torsional vibrations can be measured by using a newly developed differential-type sensor, which consists of a pair of neighboring solar cells. A vibration control method is shown by the state feedback based on the dynamics. Some of the experimental results employing the proposed control method are also shown. Author

A87-50401
AIAA GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, MONTEREY, CA, AUG. 17-19, 1987, TECHNICAL PAPERS. VOLUMES 1 & 2
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1987, p. Vol. 1, 829 p.; vol. 2, 676 p. For individual items see A87-50402 to A87-50570.

The conference presents papers on control system synthesis and analysis, differential games, control of large flexible space structures, integrated flight systems applications, and robotics for space applications. Other topics include the artificial intelligence design challenge, aircraft guidance and control in severe windshear, and missile estimation and guidance strategies. Consideration is also given to guidance and navigation for space applications, inertial instrumentation and system testing and geokinetics, missile nonlinear control and trajectory optimization, computer-aided control design, man-in-the-flight control loop, spacecraft attitude determination and control, and fault tolerant systems. K.K.

A87-50404#
CONSTRUCTION OF POSITIVE REAL COMPENSATION FOR LSS CONTROL
G. L. SLATER (Cincinnati, University, OH) and M. D. MCLAREN IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronatuics and Astronautics, 1987, p. 19-24. USAF-supported research. refs
(AIAA PAPER 87-2238)

A novel technique for the determination of positive real transfer matrices with desired eigenvalues is presented. The algorithm employs a gradient technique in an iterative manner to approach a set of desired closed-loop eigenvalues in a minimum norm fashion. The method was found to be successful for both a simple second order problem and a more complicated fourth order model of the DRAPER I structure. K.K.

A87-50413#
LOW-AUTHORITY CONTROL OF LARGE SPACE STRUCTURES BY USING TENDON CONTROL SYSTEM
Y. MUROTSU, H. OKUBO (Osaka, University, Sakai, Japan), and F. TERUI IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 90-98. refs
(AIAA PAPER 87-2249)

This paper deals with the problem of controlling the vibrations of large space structures by the use of a newly conceived torque actuation device, i.e., a tendon control system. It consists of a pair of tension cables transmitting as control torque to the structure at the moment arm position. The purpose of the study is twofold; first, to establish the analytical framework for low-authority control synthesis, and, second, to validate the proposed concept through a hardware experiment. A nonlinear optimization approach is proposed for the design of the control gains and the moment arm placement. This approach is useful when the total number of the control devices is smaller than that of the critical vibrational modes and exact pole placement is not possible. A hardware experiment has been done successfully, which shows the fundamental feasibility of the active tendon control for a highly flexible beam. However, for its practical application, further studies are needed especially on the interactions between the dynamics of the tension cables and the flexible structure. Author

A87-50414#
CONTROL OF DISTRIBUTED STRUCTURES WITH SMALL NONPROPORTIONAL DAMPING
L. MEIROVITCH and M. A. NORRIS (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 99-105. refs
(Contract F33615-86-C-3233)
(AIAA PAPER 87-2250)

Undamped distributed structures represent self-adjoint systems, admitting real eigenvalues and real orthogonal eigenfunctions. Control of self-adjoint systems can be carried out conveniently by modal control. Distributed structures with proportional damping possess the same eigenfunctions as the corresponding undamped structures, so that the same modal approach can be used in this case as well. Nonproportional damping tends to destroy the self-adjointness of the system, so that modal control is not as convenient as for undamped structures. If damping is relatively small, however, it is possible to base the control design on the self-adjoint system and still obtain satisfactory control performance. Author

A87-50415#
THE CONTROL OF LINEAR DAMPERS FOR LARGE SPACE STRUCTURES
J. K. HAVILAND, T. W. LIM, W. D. PILKEY (Virginia, University, Charlottesville), and H. POLITANSKY IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 106-116. USAF-supported research. refs
(AIAA PAPER 87-2251)

This paper addresses the problem of designing a control system for a small laboratory model of a linear proof-mass damper for large space structures. Initially a linear control law was developed, however, it was shown that, although adequate damping could be achieved at high frequencies, very little damping could be obtained at frequencies of one Herz or less with the linear law, because the system had to be constrained to operate within the physical limits set by the stops which limit the motion of the proof-mass. Because of this, rucent efforts have been concentrated on a limiting performance control law. In a preliminary study, the optimal response was calculated for a single degree-of-freedom model of a cantilever beam controlled by a proof-mass damper using the limiting-performance/minimum-time formulations. It was found that considerable damping could be achieved at low frequencies. Parameter identification was used to find a suboptimal feedback control law based on the limiting performance characteristics, this could be considered for a practical application of a limiting performance control. Author

A87-50472#

REDUCED-ORDER COMPENSATION - LQG REDUCTION VERSUS OPTIMAL PROJECTION

S. W. GREELEY and D. C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 605-616. refs
(Contract F49620-84-C-0038)
(AIAA PAPER 87-2388)

Six methods for design of reduced-order compensation, five LQG reduction techniques and the Optimal Projection theory as implemented with a simple homotopy solution algorithm, are compared using the problem posed by Enns (1984). Design results are obtained by the methods for 42 different design cases, and comparison is made with respect to closed-loop stability and transient response characteristics. Although two of the LQG-reduction methods are shown to offer distinctly superior performance, only the Optimal Projection method provided stable performance in all the cases considered. R.R.

A87-50474*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

AN ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF OUTPUT FEEDBACK VS. LINEAR QUADRATIC REGULATOR

ZORAN N. MARTINOVIC, GEORGE C. SCHAMEL, II, RAPHAEL T. HAFTKA, and WILLIAM L. HALLAUER, JR. (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 629-638. refs
(Contract NAG1-224)
(AIAA PAPER 87-2390)

This paper presents analytical and experimental comparison of three control laws for a laboratory structure designed to simulate large space structures. The first control law is the standard time invariant linear quadratic regulator with state estimation, which requires model reduction for practical implementation. This model reduction is associated with the so-called spillover instability. Two new simple direct output feedback control laws guaranteeing stability are proposed. One minimizes the maximum control force, and the other minimizes the same quadratic performance index as the linear quadratic regulator. The three control laws are found to give comparable performance for the modes retained in the reduced model. However, the standard linear quadratic regulator with state estimation provides almost no margin of stability for the unmodeled modes, while the simpler direct feedback laws provide significant stability margins to all modes. The analytical results were verified experimentally using a digital implementation of the control laws. Good agreement between the analytical predictions and experimental measurements was observed. Author

A87-50475#

COMPARISON OF DIFFERENT ATTITUDE CONTROL SCHEMES FOR LARGE COMMUNICATIONS SATELLITES

S. K. SINGH, B. N. AGRAWAL (INTELSAT, Washington, DC), and R. GRAN (Grumman Aerospace Corp., Bethpage, NY) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 639-646. refs
(AIAA PAPER 87-2391)

A comparative study of the robustness of various spacecraft body attitude control systems with structural flexibility is presented in this paper. The control systems examined are: (1) 3-Reaction Wheels (2) Body-fixed momentum wheel with offset thrusters (3) Skewed body-fixed momentum wheels with two reaction wheels. For the size of large spacecraft considered in this paper, all these systems are shown to result in satisfactory performance. In order to exhibit their relative merits, the presence of severe structural interaction had to be introduced. Comparison was then made in terms of stability, which is affected by non-colocation of actuators and sensors. Performance borne out of the nonlinear simulation with both the large flexible spacecraft and dummy unstable interacting low structural mode is illustrated. This latter study shows that a system with single body-fixed momentum wheel along pitch axis and two reaction wheels oriented along roll and yaw axes, is the most robust. Author

A87-50480#

CONTROL/DYNAMICS SIMULATION FOR PRELIMINARY SPACE STATION DESIGN

PAUL BLELLOCH (SDRC, Inc., San Diego, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 766-772. refs
(AIAA PAPER 87-2641)

A method for integrating linear control systems into a structural dynamic software module is presented. The method is in contrast to integrating a separte control software package and represents a structural analogy to control systems. The structural dynamics software module is part of an integrated package used for preliminary design analysis of the Space Station. Examples of PID attitude control and interaction with the control of a flexible manipulator arm are presented. Author

A87-50503#

AN AI-BASED MODEL-ADAPTIVE APPROACH TO FLEXIBLE STRUCTURE CONTROL

S. HANAGUD, B. J. GLASS, and A. J. CALISE (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 930-940. refs
(Contract DAAG29-82-K-0094)
(AIAA PAPER 87-2457)

An adaptive control technique for discontinuously time-varying structures is developed using model identification and parameter identification to replace controllers when large-scale discontinuous model changes occur. The controller model replacement (CMR) method, utilizing the AI techniques of heuristic search and object-oriented programming, is demonstrated for the test problem of controlling a beam for which boundary conditions change suddenly in time. A linear optimal output feedback approach is employed to design the controller, once a new model is identified. For SISO and MIMO test problems, the CMR method was found to follow the actual model more closely than a comparable explicit self-tuning regulator, yielding better stability and performance. R.R.

A87-50505*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ON-LINE IDENTIFICATION AND ATTITUDE CONTROL FOR SCOLE

R. C. MONTGOMERY, J. SHENHAR, and J. P. WILLIAMS (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute

of Aeronautics and Astronautics, 1987, p. 950-958. refs
(AIAA PAPER 87-2458)

This paper documents on-line linear least-square identification and attitude control of SCOLE, a laboratory apparatus representing an offset-feed antenna attached to the Space Shuttle. Identification is done autonomously by starting a slew maneuver in pitch or roll with reaction jets and observing the time history data of associated Euler angles when the jets are quiescent. Linear least-square analysis is used to select the parameters that best fit the output of an Autoregressive (AR) model to the data. The control effectiveness of the jets is determined in a subsequent test, again using linear least squares. The parameters so derived are used to design switching lines for time-optimal attitude control. This report describes the identification and control algorithms and the experimental apparatus and procedures used. Also, experimental data are presented that reflect the performance of the identification algorithms and the attitude control system. Author

A87-50531*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

PROPOSED CMG MOMENTUM MANAGEMENT SCHEME FOR SPACE STATION

L. R. BISHOP, R. H. BISHOP (NASA, Johnson Space Flight Center, Houston, TX), and K. L. LINDSAY (Charles Stark Draper Laboratory, Inc., Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1229-1236. refs
(Contract NAS9-17560)
(AIAA PAPER 87-2528)

A discrete control moment gyro (CMG) momentum management scheme (MMS) applicable to spacecraft with principal axes misalignments, such as the proposed NASA dual keel space station, is presented in this paper. The objective of the MMS is to minimize CMG angular momentum storage requirements for maintaining the space station near local vertical in the presence of environmental disturbances. It utilizes available environmental disturbances, namely gravity gradient torques, to minimize CMG momentum storage. The MMS is executed once per orbit and generates a commanded torque equilibrium attitude (TEA) time history which consists of a yaw, pitch and roll angle command profile. Although the algorithm is called only once per orbit to compute the TEA profile, the space station will maneuver several discrete times each orbit. Author

A87-50558*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

ADAPTIVE MOMENTUM MANAGEMENT FOR THE DUAL KEEL SPACE STATION

M. HOPKINS (NASA, Marshall Space Flight Center, Huntsville, AL) and E. HAHN (Allied-Signal, Inc., Bendix Guidance Systems Div., Teterboro, NJ) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1472-1480.
(Contract NAS8-36488)
(AIAA PAPER 87-2596)

The report discusses momentum management for a large space structure with the structure selected configuration being the Initial Orbital Configuration of the dual-keel Space Station. The external torques considered were gravity gradient and aerodynamic torques. The goal of the momentum management scheme developed is to remove the bias components of the external torques and center the cyclic components of the stored angular momentum. The scheme investigated is adaptive to uncertainties of the inertia tensor and requires only approximate knowledge of principal moments of inertia. Computational requirements are minimal and should present no implementation problem in a flight-type computer. The method proposed is shown to be effective in the presence of attitude control bandwidths as low as 0.01 radian/sec. Author

A87-50561*# Illinois Univ., Urbana.

TRACKING AND POINTING MANEUVERS WITH SLEW-EXCITED DEFORMATION SHAPING

THOMAS A. W. DWYER, III (Illinois, University, Urbana) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1503-1511. refs
(Contract NSF ECS-85-16445; NAG1-436; NAG1-613)
(AIAA PAPER 87-2599)

It is shown in this paper how it is possible to shape the slew-excited structural response of a deformable vehicle undergoing agile attitude maneuvers, so that the required fully corrected slew torque profiles can be computed on-line in closed form, and with the same bandwidth as required for the rigid body case. This is accomplished by simultaneously applying maneuver-dependent structural force controls of progressively smaller amplitudes, at the cost of progressively higher signal processing complexity of slew torque and structural force command generation. Author

A87-50562*# McDonnell-Douglas Astronautics Co., Houston, Tex.

THE DYNAMICS AND CONTROL OF THE SPACE STATION POLAR PLATFORM

M. M. WAHBAH (McDonnell Douglas Astronautics Co., Houston, TX) and G. C. ANDERSEN (NASA, Goddard Space Flight Center; Lockheed Missiles and Space Co., Inc., Greenbelt, MD) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1512-1527. refs
(AIAA PAPER 87-2600)

The Space Station polar platform will carry a variety of earth observation instruments for NASA and the National Oceanic and Atmospheric Administration. In this paper, the asymmetrical platform is modeled as three connected rigid bodies. A generalized angular momentum equation is employed to derive the rotational equations of motion. These equations are linearized and used for preliminary sizing of control devices using a classical control approach. Two control systems are considered to stabilize the platform and satisfy the pointing requirements. The first system is composed of a single variable-speed, double-gimbaled momentum wheel and the second consists of three-reaction wheels. The performance of each system is assessed using a linear optimal control approach. Author

A87-51610

GLOBAL TREATMENT OF ENERGY DISSIPATION EFFECTS FOR MULTIBODY SATELLITES

F. P. J. RIMROTT (Toronto, University, Canada) IN: IUTAM/IFToMM Symposium on Dynamics of Multibody Systems, Udine, Italy, Sept. 16-20, 1985, Proceedings . Berlin and New York, Springer-Verlag, 1986, p. 213-225.

The attitude drift of a two-body gyrostat with viscous internal energy dissipation is investigated analytically, applying a global approach. The formulations for the platform and rotor of a dual spinner are given; the energy dissipation, spin-change allotment, and kinetics are explored in detail; and expressions for the attitude drift rate and attitude stability are obtained. It is recommended that, in the practical design of satellites for attitude stability, the rotor/platform energy-dissipation ratio be made less than 1 but greater than 0. T.K.

A87-52252*# Akron Univ., Ohio.

EFFECT OF NOZZLE GEOMETRY ON THE RESISTOJET EXHAUST PLUME

LORANELL BREYLEY, JOHN S. SERAFINI (Akron, University, OH), DAVID J. HOFFMAN, and LYNETTE M. ZANA (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 10 p. refs

(Contract NAG3-637)
(AIAA PAPER 87-2121)

Five nozzle configurations were used to study the effect of geometry on the plume structure of a resistojet exhausting into a vacuum. Mass flux data in the forward and back flux regions were obtained with a cryogenically cooled quartz crystal microbalance. The propellant used was CO2 at 300 K and a mass flow rate of 0.2 g/s. The data reveal that the percent of mass flow contained within half angles of 10, 30, and 40 deg varied by less than 12 percent from a standard 20 deg half-angle cone nozzle. K.K.

A87-52965*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EQUATIONS OF MOTION FOR MANEUVERING FLEXIBLE SPACECRAFT
L. MEIROVITCH and R. D. QUINN (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Sept.-Oct. 1987, p. 453-465. refs
(Contract NAG1-225)

This paper is concerned with the derivation of the equations of motion for maneuvering flexible spacecraft both in orbit and in an earth-based laboratory. The structure is assumed to undergo large rigid-body maneuvers and small elastic deformations. A perturbation approach is presented in which the quantities defining the rigid-body maneuver are regarded as the unperturbed motion and the elastic motions and deviations from the rigid-body motions are regarded as the perturbed motion. The perturbation equations are linear, non-self-adjoint, and with time-dependent coefficients. A maneuver force distibution exciting the least amount of elastic deformation of the spacecraft is developed. Numerical results highlight the vibration caused by rotational maneuvers. Author

A87-52968#
MASS PROPERTY ESTIMATION FOR CONTROL OF ASYMMETRICAL SATELLITES
E. V. BERGMANN (Charles Stark Draper Laboratory, Inc., Cambridge, MA), B. K. WALKER (Cincinnati, University, OH), and D. R. LEVY (USAF, Space Div., Los Angeles, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 83-93) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Sept.-Oct. 1987, p. 483-491. Previously cited in issue 22, p. 3238, Accession no. A85-45866. refs

A87-52973#
MODEL REFERENCE ADAPTIVE CONTROL FOR LARGE STRUCTURAL SYSTEMS
I. H. MUFTI (National Research Council of Canada, Ottawa) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Sept.-Oct. 1987, p. 507-509.

The implicit model reference adaptive control technique is here applied to the case of collocated actuators. By constructing a suitable Liapunov function, it is shown that the ratio of position-to-rate output is limited by twice the product of the damping ratio and the lowest structural frequency. The control law is proposed in the form of integral, proportional, and relay adaptations along with the integral of the output error. C.D.

N87-20371# Martin Marietta Aerospace, Denver, Colo.
BENEFITS OF PASSIVE DAMPING AS APPLIED TO ACTIVE CONTROL OF LARGE SPACE STRUCTURES
R. N. GEHLING, H. W. HARCROW, and G. MOROSOW *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 8 p Jul. 1986
Avail: NTIS HC A12/MF A01

Active vibration and shape control of large space structures (LSS) has received a great deal of attention recently, while passive damping measures have been somewhat neglected. However, benefits may be derived from simultaneously considering both passive and active control measures to achieve certain performance requirements. Presented are results of a preliminary study of the role passive damping plays in the design and performance of active vibration control strategies. Passive dampers were incorporated into a representative LSS and their effect on candidate active control laws was investigated. Viscous dampers were implemented in time simulations with direct velocity feedback and optimal quadratic regulator control laws. The impact of passive damping on overall closed-loop performance, control system spill-over and robustness, and active control requirements was evaluated. Numerical results are presented for a representative model. The merit of designing a LSS to incorporate discrete passive dampers in the overall approach to vibration suppression is demonstrated through a reduction in demands placed upon an active control system.

N87-20380*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY FLIGHT EXPERIMENT/DYNAMIC AUGMENTATION EXPERIMENT
LEIGHTON E. YOUNG and HOMER C. PACK, JR. Feb. 1987 72 p
(NASA-TP-2690; NAS 1.60:2690) Avail: NTIS HC A04/MF A01 CSCL 10A

This report presents the objectives, design, testing, and data analyses of the Solar Array Flight Experiment/Dynamic Augmentation Experiment (SAFE/DAE) that was tested aboard Shuttle in September 1984. The SAFE was a lightweight, flat-fold array that employed a thin polyimide film (Kapton) as a substrate for the solar cells. Extension/retraction, dynamics, electrical and thermal tests, were performed. Of particular interest is the dynamic behavior of such a large lightweight structure in space. Three techniques for measuring and analyzing this behavior were employed. The methodology for performing these tests, gathering data, and data analyses are presented. The report shows that the SAFE solar array technology is ready for application and that new methods are available to assess the dynamics of large structures in space. Author

N87-20477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESISTOJET CONTROL AND POWER FOR HIGH FREQUENCY AC BUSES
ROBERT P. GRUBER 1987 33 p Presented at the 19th International Electric Propulsion Conference, Colorado Springs, Colo., 11-13 May 1987; sponsored by AIAA, DGLR and JSASS
(NASA-TM-89860; E-3527; NAS 1.15:89860; AIAA-87-0994)
Avail: NTIS HC A03/MF A01 CSCL 09C

Resistojets are operational on many geosynchronous communication satellites which all use dc power buses. Multipropellant resistojets were selected for the Initial Operating Capability (IOC) Space Station which will supply 208 V, 20 kHz power. This paper discusses resistojet heater temperature controllers and passive power regulation methods for ac power systems. A simple passive power regulation method suitable for use with regulated sinusoidal or square wave power was designed and tested using the Space Station multipropellant resistojet. The breadboard delivered 20 kHz power to the resistojet heater. Cold start surge current limiting, a power efficiency of 95 percent, and power regulation of better than 2 percent were demonstrated with a two component, 500 W braadboard power controller having a mass of 0.6 kg. Author

N87-20577# Air Force Office of Scientific Research, Bolling AFB, Washington, D.C. Aerospace Sciences.
AIR FORCE BASIC RESEARCH IN DYNAMICS AND CONTROL OF LARGE SPACE STRUCTURES
ANTHONY K. AMOS *In* Shock and Vibration Information Center The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Blast and Ground Shock, Shock Testing and Analysis p 39-58 Aug. 1986
Avail: NTIS HC A13/MF A01

The Air Force Basic Research in dynamics and control of large space structures addresses several of the many scientific and technological issues relating to the development and operation of very large and sophisticated high performance systems in the relatively unfamiliar space environment. The design challenge has motivated most of the ongoing research to date. It is perceived that these have evolved modeling concepts, computational algorithms, and performance/stability criteria capable of supporting the design process. However, analytical and experimental methods and the experience data base needed to support the validation of designs prior to commitment to launch are still sparse or nonexistent. The program is therefore in the process of shifting emphasis from the synthesis to the simulation objectives of the technologies. It is entended to embark on the development of modeling and computational capabilities needed to perform high fidelity simulation of orbital dynamics including operational maneuvers and developmental functions of deployment and assembly. B.G.

N87-20985*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
UPPER AND MIDDLE ATMOSPHERIC DENSITY MODELING REQUIREMENTS FOR SPACECRAFT DESIGN AND OPERATIONS
M. H. DAVIS, ed. (Universities Space Research Association, Boulder, Colo.), R. E. SMITH, ed., and D. L. JOHNSON, ed. Feb. 1987 290 p Workshop held in Huntsville, Ala., 19-21 1985
(Contract NAS8-36400)
(NASA-CP-2460; M-548; NAS 1.55:2460) Avail: NTIS HC A13/MF A01 CSCL 04A

Presented and discussed are concerns with applications of neutral atmospheric density models to space vehicle engineering design and operational problems. The area of concern which the atmospheric model developers and the model users considered, involved middle atmosphere (50 to 90 km altitude) and thermospheric (above 90 km) models and their engineering application. Engineering emphasis involved areas such as orbital decay and lifetime prediction along with attitude and control studies for different types of space and reentry vehicles.

N87-20988*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION MOMENTUM MANAGEMENT
V. BUCKALEW and MIRIAM HOPKINS *In its* Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations p 41-57 Feb. 1987
Avail: NTIS HC A13/MF A01 CSCL 22B

Gravity gradient stabilization is planned for the space station. Torques arise from air-drag since the center of pressure is not the same as the center of mass of the satellite. The magnitude of these torques varies depending upon the orientation of the solar panels. Adjustments are made through the use of CMG's (Control Moment Gyros). In time, if the CMG's saturate, torque must be bled off using thrusters; however, that is undesirable because it expends propellant and contaminates the local environment. The task of the engineer is to design the CMG's to handle the aerodynamic torques and design the configuration of the spacecraft to prevent, if possible, CMG saturation. For this application the long-term atmospheric density trends are of less importance than the rate of change of density within an orbit. In principle, CMG's could be designed for the worst case of maximum solar activity, but the penalty for overdesign is excess mass and cost. In summary, present models are inadequate for this application with the greatest need being a reliable prediction of maximum rates-of-change of density within an orbit. Author

N87-20989*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION CONTROL MOMENT GYRO CONTROL
ALDO BORDANO *In* NASA. Marshall Space Flight Center Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations p 59-71 Feb. 1987
Avail: NTIS HC A13/MF A01 CSCL 22B

The potential large center-of-pressure to center-of-gravity offset of the space station makes the short term, within an orbit, variations in density of primary importance. The large range of uncertainty in the prediction of solar activity will penalize the design, developments, and operation of the space station. Author

N87-21335 California Univ., Berkeley.
DYNAMICS OF FLEXIBLE STRUCTURES PERFORMING LARGE OVERALL MOTIONS: A GEOMETRICALLY-NONLINEAR APPROACH Ph.D. Thesis
LOC QUOC VU 1986 231 p
Avail: Univ. Microfilms Order No. DA8624976

The modeling of flexible structures subjected to large overall motions is discussed. Applications span diverse disciplines: from robotics and machine design to aircraft and spacecraft dynamics. Traditional approaches to this class of problems are based on the assumption of small deformations, thus relying crucially on the use of a floating reference frame. The resulting set of equations of motion is nonlinear and highly coupled in the inertia terms. By contrast, an alternative approach is proposed in which fully nonlinear structural theories, which are properly invariant with respect to superposed rigid body motions, are employed. Owing to this property, the dynamics of motion can be referred directly to the inertial frame, leading to a drastic simplification of the inertia operator (with a structure identical to that found in rigid body mechanics). Even though the methodology applies to a general class of structural elements, only a one-dimensional type (flexible rod) is considered. The dynamics of Earth-orbiting flexible satellites are completely described by the same system of equations of motion as for the fully nonlinear rod model. Applications of the proposed methodology to the dynamics of flexible multibody systems (rigid bodies with flexible appendages, all flexible chain systems, flexible closed-loop chains) are also considered. Dissert. Abstr.

N87-21969 Ohio State Univ., Columbus.
VARIABLE STRUCTURE CONTROL SYSTEM MANEUVERING OF SPACECRAFT Ph.D. Thesis
OSAMA ABDERRHMAN MOSTAFA 1986 152 p
Avail: Univ. Microfilms Order No. DA8625264

Variable structure control systems (VSCS) are a class of nonlinear systems which change the structure of the controls when a set of prescribed hypersurfaces are reached in the phase space. The theory represents a real-time implementable approach to control in contrast to algorithmic approaches, and therefore eliminates the computational burden. This dissertation applies the VSCS theory to maneuvering of a rigid spacecraft with four momentum exchange wheels and maneuvering of a flexible spacecraft. General nonlinear equations of motion are presented for the three-axes maneuver of the rigid spacecraft and for a single axis maneuver of the flexible spacecraft. Three methods are presented for designing variable structure control logics. The theory is demonstrated for set point regulation, tracking, disturbance accommodation, spin-up and robust maneuvers of specific spacecraft configurations. A practical problem in the implementation of VSCS theory is the possibility of chatter about hypersurfaces known as sliding regimes. Three methods of chatter alleviation are introduced. Specifically, the methods are: a boundary layer approach, asymptotic reaching of sliding regimes, and digital input prefiltering. Dissert. Abstr.

N87-21993*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EQUATIONS OF MOTION OF A SPACE STATION WITH EMPHASIS ON THE EFFECTS OF THE GRAVITY GRADIENT
L. P. TUELL Mar. 1987 127 p
(NASA-TM-86588; NAS 1.15:86588) Avail: NTIS HC A07/MF A01 CSCL 22B

The derivation of the equations of motion is based upon the principle of virtual work. As developed, these equations apply only to a space vehicle whose physical model consists of a rigid central carrier supporting several flexible appendages (not interconnected), smaller rigid bodies, and point masses. Clearly evident in the equations is the respect paid to the influence of the Earth's gravity field, considerably more than has been the custom in simulating vehicle motion. The effect of unpredictable crew motion is ignored. Author

N87-21994*# Astro Aerospace Corp., Carpinteria, Calif.
STRUCTURAL CONCEPTS FOR LARGE SOLAR CONCENTRATORS Final Report
JOHN M. HEDGEPETH and RICHARD K. MILLER Washington NASA 1987 66 p
(Contract NAS1-17536)
(NASA-CR-4075; NAS 1.26:4075) Avail: NTIS HC A04/MF A01 CSCL 10A

The Sunflower large solar concentrator, developed in the early 1970's, is a salient example of a high-efficiency concentrator. The newly emphasized needs for solar dynamic power on the Space Station and for large, lightweight thermal sources are outlined. Existing concepts for high efficiency reflector surfaces are examined with attention to accuracy needs for concentration rates of 1000 to 3000. Concepts using stiff reflector panels are deemed most likely to exhibit the long-term consistent accuracy necessary for low-orbit operation, particularly for the higher concentration ratios. Quantitative results are shown of the effects of surface errors for various concentration and focal-length diameter ratios. Cost effectiveness is discussed. Principal sources of high cost include the need for various dished panels for paraboloidal reflectors and the expense of ground testing and adjustment. A new configuration is presented addressing both problems, i.e., a deployable Pactruss backup structure with identical panels installed on the structure after deployment in space. Analytical results show that with reasonable pointing errors, this new concept is capable of concentration ratios greater than 2000. Author

N87-22080 California Univ., Los Angeles.
INTEGRATED CONTROL/STRUCTURE DESIGN AND ROBUSTNESS Ph.D. Thesis
ARMEN ADAMIAN 1986 196 p
Avail: Univ. Microfilms Order No. DA8702603

When a flexible structure is to be controlled actively, optimum performance is obtained by integrated, or simultaneous, design of the structure and the controller, as opposed to the common practice of designing the structure independently of control considerations and then designing a controller for a fixed structure. The primary design objective from the structural point of view usually is to minimize weight, while the control design objectives depend on the application. An important requirement for a practical control system is robustness with respect to uncertain plant parameters. Robust compensator design for fixed structures, and simultaneous control/structure design where the overall design objective combines the weight of the structure and the robustness of the closed-loop control system are discussed. For numerical optimization, robustness is represented by the sensitivity of the closed-loop eigenvalues with respect to uncertain parameters. An example illustrates the closed-loop control system with robust compensator, and two examples illustrate the optimal designs of a flexible structure along with robust compensators. Different finite element models are compared to determine models most efficient for compensator design. Dissert. Abstr.

N87-22702*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
STRUCTURAL DYNAMICS AND CONTROL INTERACTION OF FLEXIBLE STRUCTURES
ROBERT S. RYAN, ed. and HAROLD N. SCOFIELD, ed. Apr. 1987 680 p Workshop held in Huntsville, ALa., 22-24 Apr. 1986
(NASA-CP-2467-PT-1; M-554-PT-1; NAS 1.55:2467-PT-1) Avail: NTIS HC A99/MF E03 CSCL 22B

A workshop on structural dynamics and control interaction of flexible structures was held to promote technical exchange between the structural dynamics and control disciplines, foster joint technology, and provide a forum for discussing and focusing critical issues in the separate and combined areas. Issues and areas of emphasis were identified in structure-control interaction for the next generation of flexible systems.

N87-22706*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MICROPROCESSOR CONTROLLED PROOF-MASS ACTUATOR
GARNETT C. HORNER *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 101-116 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 14B

The objective of the microprocessor controlled proof-mass actuator is to develop the capability to mount a small programmable device on laboratory models. This capability will allow research in the active control of flexible structures. The approach in developing the actuator will be to mount all components as a single unit. All sensors, electronic and control devices will be mounted with the actuator. The goal for the force output capability of the actuator will be one pound force. The programmable force actuator developed has approximately a one pound force capability over the usable frequency range, which is above 2 Hz. Author

N87-22708*# Auburn Univ., Ala.
SPACE STATION/SHUTTLE ORBITER DYNAMICS DURING DOCKING
N. G. FITZ-COY and J. E. COCHRAN, JR. *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 133-174 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

Mathematical models of a reference space station configuration (Power Tower) and a Space Shuttle Orbiter are developed and used to study the dynamic behavior of the Space Station/Orbiter system just prior to and subsequent to an impulsive docking of the two spacecraft. The physical model of the space station is a collection of rigid and flexible bodies. The orbiter is modeled as a rigid body. An algorithm developed for use in digitally simulating the dynamics of the system is described and results of its application are presented. Author

N87-22714*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
OPTIMUM MIX OF PASSIVE AND ACTIVE CONTROL OF SPACE STRUCTURES
LYNN ROGERS and KEN RICHARDS (Martin Marietta Aerospace, Denver, Colo.) *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 275-292 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The objective of this research was to test vibration suppression (settling time and jitter) of a large space structure (LSS) characterized by low frequency high global vibration modes. Five percent passive damping in a large truss was analyzed, tested and correlated. A representative system article re-target analysis shows that modest levels of passive damping dramatically reduce the control energy required. LSS must incorporate passive damping from the outset. The LSS system performance will not be met by either active or passive damping alone. E.R.

N87-22715*# Control Dynamics Co., Huntsville, Ala.
ONE CONTROLLER AT A TIME (1-CAT): A MIMO DESIGN METHODOLOGY
J. R. MITCHELL and J. C. LUCAS *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 293-334 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The One Controller at a Time (1-CAT) methodology for designing digital controllers for Large Space Structures (LSS's) is introduced and illustrated. The flexible mode problem is first discussed. Next, desirable features of a LSS control system design methodology are delineated. The 1-CAT approach is presented, along with an analytical technique for carrying out the 1-CAT process. Next, 1-CAT is used to design digital controllers for the proposed Space Based Laser (SBL). Finally, the SBL design is evaluated for dynamical performance, noise rejection, and robustness. Author

N87-22717*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

STATUS REPORT AND PRELIMINARY RESULTS OF THE SPACECRAFT CONTROL LABORATORY EXPERIMENT

JEFFREY P. WILLIAMS *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 359-398 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The Spacecraft Control Laboratory Experiment (SCOLE) was conceived to provide a physical test bed for investigation of control techniques for large flexible spacecraft. The SCOLE problem is defined as two design challenges. The first challenge is to design control laws for a mathematical model of a large antenna attached to the space shuttle by a long flexible mast. The second challenge is to design and implement a control scheme on a laboratory representation of the structure modelled in the first part. Control sensors and actuators are typical of those which the control designer would have to deal with on an actual spacecraft. The primary control processing computer is representative of the capacity and speed which may be expected in actual flight computers. A brief description is given of the laboratory apparatus along with some preliminary results of structural dynamics tests and actuator effectiveness tests. Author

N87-22720*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AN OVERVIEW OF CONTROLS RESEARCH ON THE NASA LANGLEY RESEARCH CENTER GRID

RAYMOND C. MONTGOMERY *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 435-456 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

The NASA Langley Research Center has assembled a flexible grid on which control systems research can be accomplished on a two-dimensional structure that has many physically distributed sensors and actuators. The grid is a rectangular planar structure that is suspended by two cables attached to one edge so that out of plane vibrations are normal to gravity. There are six torque wheel actuators mounted to it so that torque is produced in the grid plane. Also, there are six rate gyros mounted to sense angular motion in the grid plane and eight accelerometers that measure linear acceleration normal to the grid plane. All components can be relocated to meet specific control system test requirements. Digital, analog, and hybrid control systems capability is provided in the apparatus. To date, research on this grid has been conducted in the areas of system and parameter identification, model estimation, distributed modal control, hierarchical adaptive control, and advanced redundancy management algorithms. The presentation overviews each technique and presents the most significant results generated for each area. Author

N87-22723*# Boeing Aerospace Co., Seattle, Wash.

PRECISION POINTING AND CONTROL OF FLEXIBLE SPACECRAFT

M. H. BANTELL, JR. *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 505-538 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The problem and long term objectives for the precision pointing and control of flexible spacecraft are given. The four basic objectives are stated in terms of two principle tasks. Under Task 1, robust low order controllers, improved structural modeling methods for control applications and identification methods for structural dynamics are being developed. Under Task 2, a lab test experiment for verification of control laws and system identification algorithms is being developed. For Task 1, work has focused on robust low order controller design and some initial considerations for structural modeling in control applications. For Task 2, work has focused on experiment design and fabrication, along with sensor selection and initial digital controller implementation. Conclusions are given. Author

N87-22729*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

STRUCTURAL DYNAMICS AND CONTROL INTERACTION OF FLEXIBLE STRUCTURES

ROBERT S. RYAN, ed. and HAROLD N. SCOFIELD, ed. Apr. 1987 729 p Workshop held in Huntsville, Ala., 22-24 Apr. 1986
(NASA-CP-2467-PT-2; M-554-PT-2; NAS 1.55:2467-PT-2) Avail: NTIS HC A99/MF E03 CSCL 22B

A Workshop was held to promote technical exchange between the structural dynamic and control disciplines, foster joint technology, and provide a forum for discussing and focusing critical issues in the separate and combined areas. The workshop was closed by a panel meeting. Panel members' viewpoints and their responses to questions are included.

N87-22730*# California Inst. of Tech., Pasadena.

VIBRATION SUPPRESSION BY STIFFNESS CONTROL

JAMES FANSON, THOMAS CAUGHEY, and JAY CHEN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 693-758 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

The feasibility of using piezoelectric ceramics as both sensors and actuators for vibration suppression in a lightweight, flimsy structure was demonstrated. Multimode control was achieved using one sensor and actuator pair. The Positive Position Feedback control strategy requires only knowledge of the natural frequencies of the structure. Implementation of the Positive Position Feedback used only strain measurements to achieve damping, no velocities, or acceleration are needed. All spillover is stabilizing for sufficient small gains. B.G.

N87-22731*# Texas A&M Univ., College Station.

A QUASI-ANALYTICAL METHOD FOR NON-ITERATIVE COMPUTATION OF NONLINEAR CONTROLS

J. L. JUNKINS, R. C. THOMPSON, and J. D. TURNER (Cambridge Research Associates, Mass.) *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 759-774 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

An optimal control solution process was developed for a general class of nonlinear dynamical systems. The method combines control theory, perturbation methods, and Van Loan's recent matrix exponential results. A variety of applications support the practical utility of this method. Nonlinear rigid body optimal maneuvers are routinely solved. Flexible body dynamical systems of an order greater than 40 were solved. The method fails occasionally due to poor convergence of the perturbation expansion or numerical difficulties associated with computing the matrix exponential. The method is attractive because it appears to be a good candidate for semi-automation; no initial guess is required, and it usually converges at 2nd or 3rd order in minutes of machine time. B.G.

N87-22732*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CONTROL OF FLEXIBLE STRUCTURES AND THE RESEARCH COMMUNITY

CLAUDE R. KECKLER and JON S. PYLE *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 789-840 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The Control of Flexible Structures II (CPFS) program is a complex and ambitious undertaking which addresses several critical technology areas. Among them are modeling, structural dynamics, control, and ground testing issues, which are also applicable to other large space structure programs being contemplated. This effort requires early integration of controls and structural dynamic considerations. Several technological advances must be achieved in the areas of system modeling, control synthesis and methodology, sensor/actuator development, and ground testing techniques for system evaluation and on-orbit performance prediction and verification. This program offers an opportunity for the integration of several disciplines to produce technology advances which will benefit many future programs. B.G.

N87-22734*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
MANEUVERING AND VIBRATION CONTROL OF FLEXIBLE SPACECRAFT
L. MEIROVITCH and R. D. QUINN *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 867-880 Apr. 1987
(Contract NAG1-225)
Avail: NTIS HC A99/MF E03 CSCL 22B

Equations of motion, control strategy, perturbation, rigid-body maneuvers, quasi-modal equations, and vibration control are discussed for flexible spacecraft. B.G.

N87-22736*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
PRELIMINARY EVALUATION OF A REACTION CONTROL SYSTEM FOR THE SPACE STATION
H. H. WOO and J. A. FINLEY *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 930-942 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The challenge, ground rules and criteria, some of the Reaction Control System (RCS) concepts, classical and modern design analysis, and simulation results which are applicable to the space station are presented. B.G.

N87-22737*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DUAL KEEL SPACE STATION CONTROL/STRUCTURES INTERACTION STUDY
JOHN W. YOUNG, FREDERICK J. LALLMAN, and PAUL A. COOPER *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 945-978 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

A study was made to determine the influence of truss bay size on the performance of the space station control system. The objective was to determine if any control problems existed during reboost and to assess the level of potential control/structures interaction during operation of the control moment gyros used for vertical stabilization. The models analyzed were detailed finite-element representations of the 5 meter and 9 foot growth versions of the 300 kW dual keel station. Results are presented comparing the performance of the reboost control system for both versions of the space station. Standards for comparison include flexible effects at the attitude control sensor locations and flexible contributions to pointing error at the solar collectors. Bode analysis results are presented for the attitude control system and control, structural, and damping sensitivities are examined. Author

N87-22742*# Lockheed Missiles and Space Co., Sunnyvale, Calif. Space Systems Div.
VIBRATION ISOLATION FOR LINE OF SIGHT PERFORMANCE IMPROVEMENT
J. J. RODDEN, H. J. DOUGHERTY, and W. B. HAILE *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1071-1078 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

Diagrams of the Reaction Wheel Assembly (RWA) are presented along with charts and graphs illustrating jitter error model, induced vibration tests, radial displacement transfer function, and axial displacement power spectra density. The RWA isolator specification requirements are listed. B.G.

N87-22746*# DYNACS Engineering Co., Inc., Clearwater, Fla.
NOTES ON IMPLEMENTATION OF COULOMB FRICTION IN COUPLED DYNAMICAL SIMULATIONS
R. J. VANDERVOORT and R. P. SINGH *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1197-1213 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

A coupled dynamical system is defined as an assembly of rigid/flexible bodies that may be coupled by kinematic connections. The interfaces between bodies are modeled using hinges having 0 to 6 degrees of freedom. The equations of motion are presented for a mechanical system of n flexible bodies in a topological tree configuration. The Lagrange form of the D'Alembert principle was employed to derive the equations. The equations of motion are augmented by the kinematic constraint equations. This augmentation is accomplished via the method of singular value decomposition. B.G.

N87-22752*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
ANALYTICAL DETERMINATION OF SPACE STATION RESPONSE TO CREW MOTION AND DESIGN OF SUSPENSION SYSTEM FOR MICROGRAVITY EXPERIMENTS
FRANK C. LIU *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1333-1366 Apr. 1987 Previously announced as N86-24535
(Contract NGT-01-008-021)
Avail: NTIS HC A99/MF E03 CSCL 22B

The objective of this investigation is to make analytical determination of the acceleration produced by crew motion in an orbiting space station and define design parameters for the suspension system of microgravity experiments. A simple structural model for simulation of the IOC space station is proposed. Mathematical formulation of this model provides the engineers a simple and direct tool for designing an effective suspension system. Author

N87-22753*# Martin Marietta Aerospace, Denver, Colo. Analytical Mechanics.
SPACE STATION STRUCTURAL DYNAMICS/REACTION CONTROL SYSTEM INTERACTION STUDY
M. PINNAMANENI and J. MURRAY *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1367-1394 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

The performance of the Reaction Control System is impacted by the extreme flexibility of the space station structure. The method used to analyze the periodic thrust profile of a simple form of phase plane logic is presented. The results illustrate the effect on flexible body response of the type of phase plane logic utilized and the choice of control parameters: cycle period and attitude deadband. Author

N87-22758*# Allied Bendix Aerospace, Teterboro, N.J. Guidance Systems Div.
ADAPTIVE MOMENTUM MANAGEMENT FOR LARGE SPACE STRUCTURES Final Report, 1 May 1986 - 31 Jan. 1987
E. HAHN 10 Feb. 1987 43 p
(Contract NAS8-36488)
(NASA-CR-179085; NAS 1.26:179085) Avail: NTIS HC A03/MF A01 CSCL 22B

Momentum management is discussed for a Large Space Structure (LSS) with the structure selected configuration being the Initial Orbital Configuration (IOC) of the dual keel space station. The external forces considered were gravity gradient and aerodynamic torques. The goal of the momentum management scheme developed is to remove the bias components of the external torques and center the cyclic components of the stored angular momentum. The scheme investigated is adaptive to uncertainties of the inertia tensor and requires only approximate knowledge of principle moments of inertia. Computational requirements are minimal and should present no implementation problem in a flight type computer and the method proposed is shown to be effective in the presence of attitude control bandwidths as low as .01 radian/sec. Author

N87-22761# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MOVING-BANK MULTIPLE MODEL ADAPTIVE ESTIMATION APPLIED TO FLEXIBLE SPACESTRUCTURE CONTROL M.S. Thesis
DREW A. KARNICK Dec. 1986 213 p
(AD-A178570; AFIT/GE/ENG/86D-41) Avail: NTIS HC A10/MF A01 CSCL 22B

A significant problem in estimation and control is the uncertainty of parameters in the mathematical model used in the design of controllers and/or estimators. These parameters may be unknown, varying slowly, or changing abruptly due to a failure in the physical system. These changes in parameters often necessitate the identification of parameters within the mathematical model and changing the mathematical model during a real-time control problem. This is often referred to as adaptive control and/or estimation. This thesis investigates methods of adaptive control implementing a moving-bank multiple model adaptive estimator. GRA

N87-23881# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
AN ANALYSIS OF SPACE STATION MOTION SUBJECT TO THE PARAMETRIC EXCITATION OF PERIODIC ELEVATOR MOTION M.S. Thesis
JOHN D. CHAN Dec. 1986 83 p
(AD-A179235; AFIT/GA/AA/86D-2) Avail: NTIS HC A05/MF A01 CSCL 06S

This study will derive the equations of attitude motion for a gravity gradient stabilized space station whose moments of inertia are varying with time. The equations are then linearized, after which an analytical solution of the pitch equation is developed. An examination of the stability of motion for the resulting Hill equation is presented and then compared to the solution obtained from numerical integration of the nonlinear equations. The results show that for elevator frequencies on the order of the orbit rate, motion can grow unboundedly with time. Consequently, the shape of the classical Lagrange stability region is altered. GRA

N87-23887*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTIMIZATION OF PAYLOAD MASS PLACEMENT IN A DUAL KEEL SPACE STATION
MELVIN J. FEREBEE, JR. and ROBERT B. POWERS Mar. 1987 23 p
(NASA-TM-89051; NAS 1.15:89051) Avail: NTIS HC A02/MF A01 CSCL 22B

In order to keep a Space Station in a stable low-Earth orbit, angular momentum storage and translational attitude control systems will have to be used. In order to minimize the size of these attitude control systems, the induced gravity gradient torque effects will have to be minimized. This can be done by minimizing the cross-products of inertia of the Station through the management of payload placement with the Station geometry. A derived and automated methodology is presented which utilizes mathematical nonlinear programming techniques. An optimal arrangement of a set of five payloads on a Dual Keel Space Station was found that minimized the cross products of inertia and thus the required controllability resources. Author

N87-23890*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONTROL CONSIDERATIONS FOR HIGH FREQUENCY, RESONANT, POWER PROCESSING EQUIPMENT USED IN LARGE SYSTEMS
J. W. MILDICE, K. E. SCHREINER, and F. WOLFF 1987 8 p Prepared for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa., 10-14 Aug. 1987; cosponsored by AIAA, ANS, ASME, SAE, IEEE, ACS, and AIChE
(NASA-TM-89926; E-3629; NAS 1.15:89926; AIAA-87-9353) Avail: NTIS HC A02/MF A01 CSCL 10B

Addressed is a class of resonant power processing equipment designed to be used in an integrated high frequency (20 KHz domain), utility power system for large, multi-user spacecraft and other aerospace vehicles. It describes a hardware approach, which has been the basis for parametric and physical data used to justify the selection of high frequency ac as the PMAD baseline for the space station. This paper is part of a larger effort undertaken by NASA and General Dynamics to be sure that all potential space station contractors and other aerospace power system designers understand and can comfortably use this technology, which is now widely used in the commercial sector. In this paper, we will examine control requirements, stability, and operational modes; and their hardware impacts from an integrated system point of view. The current space station PMAD system will provide the overall requirements model to develop an understanding of the performance of this type of system with regard to: (1) regulation; (2) power bus stability and voltage control; (3) source impedance; (4) transient responses; (5) power factor effects, and (6) limits and overloads. Author

N87-24029# Oak Ridge National Lab., Tenn.
APPLICATION OF ADVANCED FLYWHEEL TECHNOLOGY FOR ENERGY STORAGE ON SPACE STATION
M. OLSZEWSKI Apr. 1987 11 p Presented at the Space Electrochemical Research and Technology Conference, Cleveland, Ohio, 14 Apr. 1987
(Contract DE-AC05-84OR-21400)
(DE87-007657; CONF-8704101-1) Avail: NTIS HC A02/MF A01

In space power applications where solar inputs are the primary thermal source, energy storage is necessary to provide a continuous power supply during the eclipse portion of the orbit. Because of their potentially high storage density, flywheels are being considered for use as the storage system on the proposed orbiting space station. During the past several years graphite fiber technology has advanced, leading to significant gains in flywheel storage density. Use of these improved fibers in experimental flywheel rims has resulted in ultimate storage densities of 878 kJ/kg. With these high-strength graphite fibers, operational storage densities for flywheel storage modules applicable to the space station power storage could reach 200 kJ/kg. This module would also be volumetrically efficient occupying only about 1 cu m. Because the size and mass of the flywheel storage module are controlled by the storage density, improvements in fiber strength can have a significant impact on these values. With the improvements anticipated within the next five years, operational storage density on the order of 325 kJ/kg may be possible for the flywheel module. DOE

N87-24490# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
ATTITUDE AND ORIENTATION SYSTEM (AOCS) TASKS ON RENDEZVOUS AND DOCKING (RVD) (DOCKING-UNDOCKING PHASES). ARCHITECTURE OF THE WHOLE SIMULATOR, VOLUME 2 Final Report
Paris, France ESA Feb. 1986 270 p
(Contract ESA-4750/81-NL-AK(SC))
(LP-RP-AI-204-VOL-2; ESA-CR(P)-2313-VOL-2; ETN-87-99869)
Avail: NTIS HC A12/MF A01

The architecture of a spacecraft docking simulator is described. The main functions are: geometrical definition of the spacecraft shape and of the interfacing docking mechanism; dynamic definition of the spacecraft in terms of mass, inertia, stiffness, damping, flexible eigenvectors, and eigenvalues; geometrical interference analysis, localization of the impact point, force or impulse exchanged, integration step control (PREP); preparation and manipulation of the input-output information flow between PREP and DCAP-1; motion simulation (DCAP-1); postelaboration of the output of DCAP-1, reconstruction of the whole geometry; and its visualization. ESA

N87-24491# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
ATTITUDE AND ORIENTATION CONTROL SYSTEM (AOCS) TASKS ON RENDEZVOUS AND DOCKING (RVD) (DOCKING-UNDOCKING PHASES). SIMULATION SET-UP AND RESULTS, VOLUME 3 Final Report
Paris, France ESA Feb. 1986 151 p
(Contract ESA-4750/81-NL-AK(SC))
(LP-RP-AI-204-VOL-3; ESA-CR(P)-2313-VOL-3; ETN-87-99870)
Avail: NTIS HC A08/MF A01

Simulations of cone-cone docking between two rigid bodies; cone-cone docking with a flexible target; and probe-cone docking with rigid target and chaser were performed. Results show that a general purpose DCAP-1 integrated software dedicated to docking is unfeasible. The DCAP code has problems in handling system nontopology due to the way it considers hinges. Ways to overcome these problems are suggested. ESA

N87-24498*# General Dynamics Corp., Fort Worth, Tex.
LARGE SPACECRAFT POINTING AND SHAPE CONTROL
ARTHUR L. HALE *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 603-635 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The overall objective of this program was the development of control algorithms that allow the concurrent operation of slewing, pointing, vibration, and shape control subsystems. This objective is important for near-term space surveillance missions that require the rapid retargeting and precise pointing of large flexible satellites. The success of these missions requires the design and concurrent operation of the various interacting control subsystems. There were two phases conducted: phase 1 was mathematical model development, and phase 2 was control development. The program is detailed and major conclusions given. Author

N87-24502*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROLS-STRUCTURES-ELECTROMAGNETICS INTERACTION PROGRAM
WILLIAM L. GRANTHAM, MARION C. BAILEY, WENDELL K. BELVIN, and JEFFREY P. WILLIAMS *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 701-715 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

A technology development program is described involving Controls Structures Electromagnetics Interaction (CSEI) for large space structures. The CSEI program was developed as part of the continuing effort following the successful kinematic deployment and RF tests of the 15 meter Hoop/Column antenna. One lesson learned was the importance of making reflector surface adjustment after fabrication and deployment. Given are program objectives, ground based test configuration, Intelsat adaptive feed, reflector shape prediction model, control experiment concepts, master schedule, and Control Of Flexible Structures-II (COFS-II) baseline configuration. Author

N87-24505*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COFS 3 MULTIBODY DYNAMICS AND CONTROL TECHNOLOGY
ROBERT LETCHWORTH, PAUL E. MCGOWAN, and MARC J. GRONET (Lockheed Missiles and Space Co., Sunnyvale, Calif.) *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 757-766 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

One of the results from the model definition study showed that the maximum scale factor for a replica model is .25. This is dictated by the fixed dimensions of the Large Spacecraft Lab. Replica scaling laws were applied to simplified theoretical models of joints and the joint/tube/joint system. The practical interpretation of the results for the specific Space Station configuration under study yielded a number of conclusions which are briefly discussed. Detailed suspension analyses were conducted to evaluate the ability of the suspended scale model to emulate the dynamic behavior of the free-free Space Station. The results indicated only a slight preference for smaller scales. A candidate erectable Space Station joint was fabricated at full scale, 1/4 scale and 1/3 scale in order to assess the comparability of the scaled joints to the full scale behavior. Another important question discussed is how well the inherent damping characteristics of the scaled joints compare to those of the full scale joint. The preliminary definition study yielded three separate scale factor recommendations for the scale model. Author

N87-24507*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL TECHNOLOGY OVERVIEW IN CSI
J. B. DAHLGREN and A. F. TOLIVAR *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 767-778 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

A brief control technology overview is given in Control Structures Interaction (CSI) by illustrating that many future NASA mission present significant challenges as represented by missions having a significantly increased number of important system states which may require control and by identifying key CSI technology needs. The JPL CSI related technology developments are discussed to illustrate that some of the identified control needs are being pursued. Since experimental confirmation of the assumptions inherent in the CSI technology is critically important to establishing its readiness for space program applications, the areas of ground and flight validation require high priority. Author

N87-24509*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRUCTURAL CONTROL BY THE USE OF PIEZOELECTRIC ACTIVE MEMBERS
J. L. FANSON and J.-C. CHEN *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 809-829 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

Large Space Structures (LSS) exhibit characteristics which make the LSS control problem different form other control problems. LSS will most likely exhibit low frequency, densely spaced and lightly damped modes. In theory, the number of these modes is infinite. Because these structures are flexible, Vibration Suppression (VS) is an important aspect of LSS operation. In terms of VS, the control actuators should be as low mass as possible, have infinite bandwidth, and be electrically powered. It is proposed that actuators be built into the structure as dual purpose structural elements. A piezoelectric active member is proposed for the control of LSS. Such a device would consist of a piezoelectric actuator and sensor for measuring strain, and screwjack actuator in series for use in quasi-static shape control. An experiment simulates an active member using piezoelectric ceramic thin sheet material on a thin, uniform cantilever beam. The feasibility of using the piezoelectric materials for VS on LSS was demonstrated. Positive positive feedback as a VS control strategy was implemented. Multi-mode VS was achieved with dramatic reduction in dynamic response. E.R.

N87-24511*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SLEW MANEUVERS ON THE SCOLE LABORATORY FACILITY
JEFFREY P. WILLIAMS *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 851-867 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The Spacecraft Control Laboratory Experiment (SCOLE) was conceived to provide a physical test bed for the investigation of control techniques for large flexible spacecraft. The control problems studied are slewing maneuvers and pointing operations. The slew is defined as a minimum time maneuver to bring the antenna line-of-sight (LOS) pointing to within an error limit of the pointing target. The second objective is to rotate about the LOS within the 0.02 degree error limit. The SCOLE problem is defined as two design challenges: control laws for a mathematical model of a large antenna attached to the Space Shuttle by a long flexible mast; and a control scheme on a laboratory representation of the structure modelled on the control laws. Control sensors and actuators are typical of those which the control designer would have to deal with on an actual spacecraft. Computational facilities consist of microcomputer based central processing units with appropriate analog interfaces for implementation of the primary control system, and the attitude estimation algorithm. Preliminary results of some slewing control experiments are given. Author

N87-24512*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESEARCH IN SLEWING AND TRACKING CONTROL
JER-NAN JUANG and JAMES D. TURNER (Cambridge Research Associates, Mass.) *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 659-680 Jun. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

Technology areas are identified in which better analytical and/or experimental methods are needed to adequately and accurately control the dynamic responses of multibody space platforms such as the Space Station and the Radiometer Spacecraft. A generic space station model is used to experimentally evaluate current control technologies and a radiometer spacecraft model is used to numerically test a new theoretical development for nonlinear three-axis maneuvers. Active suppression of flexible body vibrations induced by large angle maneuvers is studied with multiple torque inputs and multiple measurement outputs. These active suppression tests identify the hardware requirements and adequacy of various controller designs. Author

N87-24513*# University of Southern California, Los Angeles. Dept. of Civil Engineering.
EVALUATION OF ON-LINE PULSE CONTROL FOR VIBRATION SUPPRESSION IN FLEXIBLE SPACECRAFT Final Technical Report
SAMI F. MASRI 13 Jul. 1987 32 p
(Contract NAG1-636)
(NASA-CR-180391; NAS 1.26:180391; USC-53-4507-0031)
Avail: NTIS HC A03/MF A01 CSCL 22B

A numerical simulation was performed, by means of a large-scale finite element code capable of handling large deformations and/or nonlinear behavior, to investigate the suitability of the nonlinear pulse-control algorithm to suppress the vibrations induced in the Spacecraft Control Laboratory Experiment (SCOLE) components under realistic maneuvers. Among the topics investigated were the effects of various control parameters on the efficiency and robustness of the vibration control algorithm. Advanced nonlinear control techniques were applied to an idealized model of some of the SCOLE components to develop an efficient algorithm to determine the optimal locations of point actuators, considering the hardware on the SCOLE project as distributed in nature. The control was obtained from a quadratic optimization criterion, given in terms of the state variables of the distributed system. An experimental investigation was performed on a model flexible structure resembling the essential features of the SCOLE components, and electrodynamic and electrohydraulic actuators were used to investigate the applicability of the control algorithm with such devices in addition to mass-ejection pulse generators using compressed air. B.G.

N87-24514# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
ATTITUDE AND ORIENTATION CONTROL SYSTEM (AOCS) TASKS ON RENDEZVOUS AND DOCKING (RVD) (DOCKING-UNDOCKING PHASES). DOCKING-UNDOCKING PHASE ANALYSIS Final Report
Paris, France ESA Feb. 1986 138 p
(Contract ESA-4750/81-NL-AK(SC))
(LP-RP-AI-204-VOL-1; ESA-CR(P)-2313-VOL-1; ETN-87-99666)
Avail: NTIS HC A07/MF A01

The docking and undocking phases that comprise all operations leading from the first physical contact to the integral configuration of assembled spacecraft, and operations necessary to separate the two satellites in case of malfunctioning of one of them were analyzed. Mathematical models are obtained from this analysis in order to simulate these phases using the DCAP-1 program and to obtain preliminary design evaluations and requirements for the relevant docking subsystems. A probe-drogue type mechanism, including mechanical damping; and the docking between rigid interfaces are considered. ESA

N87-24521*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DISTRIBUTED CONTROL USING LINEAR MOMENTUM EXCHANGE DEVICES
J. P. SHARKEY, HENRY WAITES, and G. B. DOANE, III (Control Dynamics Co., Huntsville, Ala.) Jun. 1987 50 p
(NASA-TM-100308; NAS 1.15:100308) Avail: NTIS HC A03/MF A01 CSCL 22B

MSFC has successfully employed the use of the Vibrational Control of Space Structures (VCOSS) Linear Momentum Exchange Devices (LMEDs), which was an outgrowth of the Air Force Wright Aeronautical Laboratory (AFWAL) program, in a distributed control experiment. The control experiment was conducted in MSFC's Ground Facility for Large Space Structures Control Verification (GF/LSSCV). The GF/LSSCV's test article was well suited for this experiment in that the LMED could be judiciously placed on the ASTROMAST. The LMED placements were such that vibrational mode information could be extracted from the accelerometers on the LMED. The LMED accelerometer information was processed by the control algorithms so that the LMED masses could be accelerated to produce forces which would dampen the vibrational modes of interest. Experimental results are presented showing the LMED's capabilities. Author

N87-24723*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CHARACTERIZATION AND HARDWARE MODIFICATION OF LINEAR MOMENTUM EXCHANGE DEVICES
GEORGE D. EDGEMON, SALLY CURTIS (Control Dynamics Co., Huntsville, Ala.), and HENRY B. WAITES Mar. 1987 44 p
(NASA-TM-86594; NAS 1.15:86594) Avail: NTIS HC A03/MF A01 CSCL 20K

A sequence of modifications were made on the TRW Linear Momentum Exchange Devices (LMEDs) which were supplied for a joint MSFC/Air Force Wright Aeronautical Laboratory (AFWAL) control venture called Vibrational Control of Space Structures (VCOSS)-II. The modifications were necessary to alleviate and assuage the LMED nonlinearities. Extensive discussion of the LMED modification are presented along with the test plan, test results and conclusions. In addition, a chronology of events, relative to the LMED changes, is given. Author

N87-25350# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
SOME PROBLEMS IN THE CONTROL OF LARGE SPACE STRUCTURES Final Report, 1 Jan. - 30 Jun. 1986
LEONARD MEIROVITCH 16 Dec. 1986 58 p
(Contract AF-AFOSR-0017-83)
(AD-A179989; AFOSR-87-0426TR) Avail: NTIS HC A04/MF A01 CSCL 22B

Work during this period has been concerned with control of traveling waves in structures and developments in the control of distributed structures. In modal control of traveling waves, the question can be raised whether actuator forces at points removed from a given disturbance can begin working before the arrival of the disturbance. This question is prompted by the fact that modal forces begin acting at $t = 0$. However, the modal forces are not the actual forces, although the actual actuator forces are linear combinations of the modal forces. It is demonstrated that these combinations are such that the control forces tend to concentrate in the immediate vicinity of the disturbance and tend to vanish at points removed from the disturbance. One problem in the control of distributed structures is that control implementation must be carried out by discrete actuators. In using direct feedback, whereby the sensors and actuators are collocated and the actuator input depends only on the sensor output at the same location, asymptotic stability can be virtually guaranteed. Problems arise when one desires to place the closed-loop poles. It appears that there is some incompatibility between direct feedback and pole placement. In particular, in placing the poles for a number of controlled modes, the possibility of destabilizing uncontrolled modes exists. GRA

N87-25352# Army Military Personnel Center, Alexandria, Va.
SUBOPTIMAL CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES EXPERIENCING ROTATIONAL DYNAMICS NONLINEARITIES Final Report
GEORGE D. MITROKA 8 May 1987 102 p
(AD-A180606) Avail: NTIS HC A06/MF A01 CSCL 22B

Developed is a method to determine a suboptimal smooth trajectory for large flexible space structures during rotational slewing maneuvers. It consists of minimizing the quadratic integral of the corresponding second time derivative of the generalized coordinate subject to specified boundary conditions. A parametric study examined the consequences of varying the number of design parameters and the number of specified boundary conditions. Study results include: (1) Additional degrees of freedom reduce the curvature of the trajectory, reduce the peak maneuver angle rate and only slightly increase the peak rigid-body torques on the structure during slewing maneuvers; (2) Additional boundary conditions result in smoother transitions at the end points between targeting maneuvers and increase the peak maneuver angle rate and rigid-body torques by a larger percentage than do additional design parameters. Next, planar dynamics equations of motion for a uniform, inextensible, cantilevered beam capable of small transverse deformations and which retain the rotational (centrifugal) nonlinearities are derived via Newton's Laws, nondimensionalized and cast into a form suitable for numerical integration. GRA

N87-25355*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DYNAMICS DURING THRUST MANEUVERS OF FLEXIBLE SPINNING SATELLITES WITH AXIAL AND RADIAL BOOMS
R. W. LONGMAN (Columbia Univ., New York.) and J. V. FEDOR *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics p 13-18 Dec. 1986
Avail: NTIS HC A22/MF A01 CSCL 22B

The dynamic response to operational maneuvers of spinning symmetric spacecraft with radial and axial booms was analyzed as part of the prelaunch dynamic analysis of the ISEE-3 spacecraft placed in a halo orbit around an Earth-Sun libration point, and later renamed ICE when it was directed to fly-by comet Giacobini-Zinner. The results presented use simple spacecraft models, and frequently give predictions that are good and easily obtained when the results from using a general purpose multibody dynamics program were very time consuming to obtain. Deployment of radial booms, spin-up after partial deployment, stationkeeping, and trajectory changes are analyzed. The latter two can involve both axial thrusting and pulsed radial thrusting once per revolution. ESA

N87-25356# Indian Inst. of Science, Bangalore.
DYNAMICS OF AN ACTIVELY CONTROLLED FLEXIBLE EARTH OBSERVATION SATELLITE
S. K. SHRIVASTAVA, P. S. GOEL (Indian Space Research Organization, Bangalore.), M. SEETHARAMABHAT, and A. G. SREENATHA *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics p 19-24 Dec. 1986 Sponsored by the Indian Space Research Organization
Avail: NTIS HC A22/MF A01

Attitude and flexural dynamics of an Earth-oriented satellite with a rigid main body and two large rectangular flexible Sun-tracking solar panels are presented. It is controlled using three reaction wheels operating on PWPFM logic with a modified Schmitt trigger and attitude sensors. The governing equations being highly nonlinear and coupled, numerical solution is resorted to. The system parameters corresponding to those of the Indian Remote Sensing satellite are used for the simulation. After studying the system performance, a modified controller with a 12th order Kalman filter and observer introduced to reduce the effects of the sensor noise and to improve the system characteristics is considered. The effects of sampling and quantization of the sensor output are also studied. ESA

N87-25358# Rome Univ. (Italy). Dept. of Informatica e Sistemistica.
SAMPLED NONLINEAR CONTROL FOR LARGE ANGLE MANEUVERS OF FLEXIBLE SPACECRAFT
S. MONACO, D. N. CYROT, and S. STORNELLI (Telespazio, S.p.A., Rome, Italy) *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics p 31-38 Dec. 1986 Sponsored by Telespazio S.P.A.
Avail: NTIS HC A22/MF A01

A method for the design of attitude control systems for flexible spacecraft is presented. The design procedure employs input-output linearization and stabilization techniques; computation of the sampled-data control laws, and compensation techniques are applied to reduce the influence of the flexible part on the control system design. An idealized test vehicle subject to a variety of control laws was simulated. The improvements obtained by using a sampled-data scheme with an extended control are evident from the results of the simulations. ESA

N87-25360# Technische Hochschule, Darmstadt (West Germany). Inst. fuer Mechanik II.
ACTIVE VIBRATION DAMPING OF FLEXIBLE STRUCTURES USING THE TRAVELING WAVE APPROACH
P. HAGEDORN and J. T. SCHMIDT *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics p 47-52 Dec. 1986 Sponsored by the Stiftung Volkswagenwerk
Avail: NTIS HC A22/MF A01

A traveling wave approach for the vibration control of networks of slender flexible structural components is presented. The performance of the resulting controller is evaluated and compared with a classical modal controller using a simple model of a prestressed string. Both controllers are tested in numerical simulations. The traveling wave approach is demonstrated to have significant advantages. In particular, it is insensitive to a change in system boundary conditions. ESA

N87-25365# Politecnico di Milano (Italy). Dipt. Ingegneria Aerospaziale.
AUTOMATIC DOCKING MANEUVER AND ATTITUDE CONTROL SYSTEM
AMALIA ERCOLI FINZI and F. VENDITTI *In* ESA Proceedings of the Second International Symposium on Spacecraft Flight Dynamics p 321-326 Dec. 1986
Avail: NTIS HC A22/MF A01

The interaction between the automatic docking maneuver and the attitude dynamics of the involved spacecraft is analyzed, as far as the docking maneuver behavior is concerned. Three different docking concepts are investigated by dedicated computer dynamics simulation programs. The simulations consider rigid bodies and the presence of a flexible element between the docking port and the main body on one spacecraft; and with the docking port axis on each vehicle aligned with the center of mass and with large arms with respect to it. The need for proper attitude control systems is established; the importance of energy dissipation sources is shown. ESA

N87-25601*# Control Dynamics Co., Huntsville, Ala.
CONTACT DYNAMICS MATH MODEL Interim Report
JOHN R. GLAESE and PATRICK A. TOBBE Apr. 1986 95 p
(Contract NAS8-36570)
(NASA-CR-179147; NAS 1.26:179147) Avail: NTIS HC A05/MF A01 CSCL 09B

The Space Station Mechanism Test Bed consists of a hydraulically driven, computer controlled six degree of freedom (DOF) motion system with which docking, berthing, and other mechanisms can be evaluated. Measured contact forces and moments are provided to the simulation host computer to enable representation of orbital contact dynamics. This report describes the development of a generalized math model which represents the relative motion between two rigid orbiting vehicles. The model allows motion in six DOF for each body, with no vehicle size limitation. The rotational and translational equations of motion are derived. The method used to transform the forces and moments from the sensor location to the vehicles' centers of mass is also explained. Two math models of docking mechanisms, a simple translational spring and the Remote Manipulator System end effector, are presented along with simulation results. The translational spring model is used in an attempt to verify the simulation with compensated hardware in the loop results. M.G.

N87-25805# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.

DEVELOPMENT OF INTELLIGENT STRUCTURES USING FINITE CONTROL ELEMENTS IN A HIERARCHIC AND DISTRIBUTED CONTROL SYSTEM Final Report, 15 May 1985 - 14 Jan. 1986

DAVID W. MILLER, BENJAMIN A. WARD, EDWARD F. CRAWLEY, and WILLIAM WIDNALL 12 Jan. 1987 324 p
(Contract F49620-84-K-0010)
(AD-A179711; MIT-SSL-1-87; AFOSR-87-0560TR) Avail: NTIS HC A14/MF A01 CSCL 22B

Conclusions are drawn from the theoretical optimization of inertial reaction devices. Three different optimization procedures yielded almost identical absorber designs providing confidence in the tuning process. The optimal passive components of the control actuator were found to be equal to those of the optimal absorber. This allows passive damping to be added without significant mass penalty. When using an inertial device to increase damping in several modes, it is desirable to tune the frequency of the device to the lowest mode and adjust the damping accordingly. Experimentally, an inertial reaction device was used effectively as both a passive vibration absorber and a control actuator, passively tuned as an absorber, verifying the results of the tuning analysis that stated that passive tuning compliments active control. This dual purpose device resulted in a mass savings, increased modal controllability, and reduced target mode disturbance transmission. Additional passive damping increases gain margin for feedback systems that are conditionally stable and allows a form of passive damping enhancement in the event of control system failure. These space realizable experiments were found to be important in determining performance limitations due to instrumentation instabilities, friction in relative motion actuators, and actuator saturation at low frequencies. Uniformity in the positive definite, dual feedback matrix allowed better performance before the onset of instrumentation. GRA

N87-26038*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.

MINIMUM TIME ATTITUDE SLEWING MANEUVERS OF A RIGID SPACECRAFT

FEIYUE LI and PETER M. BAINUM 1987 13 p Proposed for presentation at the AIAA 26th Aerospace Sciences Meeting, Reno, Nev., 11-14 Jan. 1988
(Contract NSG-1414)
(NASA-CR-181130; NAS 1.26:181130) Avail: NTIS HC A02/MF A01 CSCL 01C

The problems of large-angle attitude maneuvers of a spacecraft have gained much consideration in recent years. The configurations of the spacecraft considered are: completely rigid, a combination of rigid and flexible parts, or gyrostat-type systems. The performance indices usually include minimum torque integration, power criterion, and frequency-shaped cost functionals. The minimum time slewing problem of a rigid spacecraft was examined. Optimal control theory (Maximum Principal) was applied to the slewing motion of a general rigid spacecraft. Control torque about all three axes was computed. The equations for the system are composed of the Euler dynamical equations in the spacecraft body axes and the quaternion kinematical equation. By introducing the costates for the quaternion and the angular velocity, the Hamiltonian of the system can be formed and the optimal control obtained. Finally the methods are applied to the SCOLE slewing motion. The control variables include three control moments on the Shuttle and two control forces on the reflector. Numerical results are discussed. B.G.

N87-26700*# Texas A&M Univ., College Station. Dept. of Mechanical Engineering.

ACTIVE VIBRATION CONTROL IN MICROGRAVITY ENVIRONMENT

CARL H. GERHOLD *In* NASA. Lyndon B. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1986, Volume 1 29 p Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 05A

The low gravity environment of the space station is suitable for experiments or manufacturing processes which require near zero gravity. An experiment was fabricated to test the validity of the active control process and to verify the flow and control parameters identified in a theoretical model. Zero gravity is approximated in the horizontal plane using a low friction air bearing table. An analog control system was designed to activate calibrated air jets when displacement of the test mass is sensed. The experiment demonstrates that an air jet control system introduces an effective damping factor to control oscillatory response. The amount of damping as well as the flow parameters, such as pressure drop across the valve and flow rate of air, are verified by the analytical model. Author

N87-26966# Naval Postgraduate School, Monterey, Calif.

DYNAMIC ANALYSIS OF THE FLEXIBLE BOOM IN THE N-ROSS SATELLITE M.S. Thesis

CHOONG S. KANG Mar. 1987 149 p
(AD-A181488) Avail: NTIS HC A07/MF A01 CSCL 22A

Accurate ocean data is essential for successful fleet operation. The N-ROSS Satellite, which is being developed for this mission, will carry a Low Frequency Microwave Radiometer (LFMR). The LFMR consists of large flexible reflector and boom and spins at 15 r.p.m. The effects of the flexibility of the boom, the spin-up procedure and the structural damping on the pointing error of the LFMR are investigated by performing the dynamic simulation using the Dynamic Simulation Language. Two cases of boom material, aluminum alloy and the graphite/epoxy composite material, are analyzed and the results are compared. The simulation and analysis results are presented in graphical forms. Author (GRA)

N87-26970 Virginia Univ., Charlottesville.

THEORY AND APPLICATION OF LINEAR SERVO DAMPERS FOR LARGE SCALE SPACE STRUCTURES Ph.D. Thesis

MICHAEL FREDERICK MALLETTE 1986 244 p
Avail: Univ. Microfilms Order No. DA8705681

An investigation was made of control laws of several different servo control circuits for use in damping the vibrations of large scale space structures. A proof-mass type, structure-borne displacement device was tested as a linear servo actuator that is a component of digital control systems. These systems are hardware implementations of certain mathematical models of governing equations that show higher damping figures of merit for certain control circuits in regard to stability and response. The result was a general approach to removal of structural energy from the standpoint of design criterion that includes control law shaping predicted from open loop design, frequency limitations, and selectability of integral exponents as gain values. The critical elements in the development of the damper are the electronic digital signal processor and the associated software used to boot-strap the system up to the final Z-80 microprocessor ground based simulator, and the nearly pure iron pole pieces for the toroidal magnetic field containment into which is coupled a solenoid coil to produce control forces. Dissert. Abstr.

N87-27704*# Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.

DIGITAL CONTROL SYSTEM FOR SPACE STRUCTURE DAMPERS Annual Report

J. K. HAVILAND Sep. 1985 96 p

(Contract NAG1-349)
(NASA-CR-181253; NAS 1.26:181253; UVA/528224-MAE86-105)
Avail: NTIS HC A02/MF A01 CSCL 22B

A digital controller was developed using an SKD-51 System Design Kit, which incorporates an 8031 microcontroller. The necessary interfaces were installed in the wire wrap area of the SKD-51 and a pulse width modulator was developed to drive the coil of the actuator. Also, control equations were developed, using floating-point arithmetic. The design of the digital control system is emphasized, and it is shown that, provided certain rules are followed, an adequate design can be achieved. It is recommended that the so-called w-plane design method be used, and that the time elapsed before output of the up-dated coil-force signal be kept as small as possible. However, the cycle time for the controller should be watched carefully, because very small values for this time can lead to digital noise. Author

N87-27706# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Space Flight Dynamics Section.
STUDY ON INVESTIGATION OF THE ATTITUDE CONTROL OF LARGE FLEXIBLE SPACECRAFT. PHASE 1, VOLUME 1: TECHNICAL REPORT Final Report
G. HEIMBOLD, comp., TH. LANGE, comp., B. SCHAEFER, R. STAPF, H. ROTH, comp., and G. THIEME, comp. (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) Paris, France ESA Feb. 1984 220 p
(Contract ESTEC-5310/82-NL-BI)
(ESA-CR(P)-2361-VOL-1; ETN-87-90462) Avail: NTIS HC A10/MF A01

Different techniques of attitude and vibration control were applied to structural dynamic models, representative of large flexible spacecraft. The high order systems are reduced to tractable design models using different order reduction methods. A two staged controller design was applied, including sensor/actuator positioning, low authority control for structural damping augmentation, and superimposed high authority control. Fundamental problems to be studied in a laboratory experiment were derived. A test structure represented by a rectangular flexible plate suspended by wires is proposed. The test procedure envisaged includes an ideal approach with respect to the peripheral hardware, and a realistic test where specific performance limitations can be included. ESA

N87-27707# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Space Flight Dynamics Section.
STUDY ON INVESTIGATION OF THE ATTITUDE CONTROL OF LARGE FLEXIBLE SPACECRAFT. PHASE 2, VOLUME 1: EXECUTIVE SUMMARY Final Report
G. HEIMBOLD, H. HOLZACH, TH. LANGE, comp., B. SCHAEFER, R. STAPF, G. THIEME, and N. DUSKE (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) Paris, France ESA Mar. 1985 55 p
(Contract ESTEC-5310/82-NL-BI)
(ESA-CR(P)-2361-VOL-1; ETN-87-90463) Avail: NTIS HC A04/MF A01

The hardware, experimental and theoretical modeling of the test element, and development and implementation of the controller software for large flexible spacecraft model simulation are described. Based on a finite element method structural model, confirmed by the experimental results, different sensor and actuator positions are derived. For selected configurations, active vibration and attitude controller design is performed. The feasibility of the approaches is proved by a computer performance simulation. The implementation of control laws is realized by an array processor real time routine. The experiments to be performed are summarized. ESA

N87-27708# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
STUDY ON THE INVESTIGATION OF THE ATTITUDE CONTROL OF LARGE FLEXIBLE SPACECRAFT. PHASE 2, VOLUME 2: TECHNICAL REPORT Final Report
Paris, France ESA 1986 267 p
(Contract ESTEC-5310/82-NL-BI)
(ESA-CR(P)-2361-VOL-2; ETN-87-90464) Avail: NTIS HC A12/MF A01

The hardware, experimental and theoretical modeling of the test element, and development and implementation of the controller software for large flexible spacecraft model simulation are described. Based on a finite element method structural model, confirmed by the experimental results, different sensor and actuator positions are derived. For selected configurations, active vibration and attitude controller design is performed. The feasibility of the approaches is proved by a computer performance simulation. The implementation of control laws is realized by an array processor real time routine. The experiments to be performed are summarized. ESA

N87-27709# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Space Flight Dynamics Section.
STUDY ON INVESTIGATION OF THE ATTITUDE CONTROL OF LARGE FLEXIBLE SPACECRAFT, PHASE 3 Final Report
G. HEIMBOLD, TH. LANGE, comp., N. DUSKE, and G. THIEME Paris, France ESA Oct. 1986 207 p
(Contract ESTEC-5310/82-NL-BI)
(ESA-CR(P)-2361-VOL-4; ETN-87-90465) Avail: NTIS HC A10/MF A01

A large flexible spacecraft (LFS) was simulated by a plate suspended from wires. Results revealed constraints, which were not predicted, so the controller was redesigned, to give reduced gain configurations, which the laboratory experience showed feasible. The first test results exhibit considerable discrepancies with respect to the theoretical predictions. A laboratory reference model was developed for theoretical performance prediction. Applying this to the tests using the updated controller design, satisfactory agreement with the test results is achieved. The modeling uncertainty has severe consequences with respect to LFS controller design, where usually the aspect is often considered not to play such an important role. It is concluded that the controller design approaches must be checked and possibly developed to end up at feasible designs for space applications. ESA

N87-27712*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES X, PART 1 Final Report
PETER M. BAINUM, A. S. S. R. REDDY, FEIYUE LI, and CHEICK M. DIARRA Aug. 1987 72 p
(Contract NSG-1414)
(NASA-CR-181287; NAS 1.26:181287) Avail: NTIS HC A04/MF A01 CSCL 22B

The effect of delay in the control system input on the stability of a continuously acting controller which is designed without considering the delay is studied. The stability analysis of a second order plant is studied analytically and verified numerically. For this example it is found that the system becomes unstable for a delay which is equivalent to only 16 percent of its natural period of motion. It is also observed that even a small amount of natural damping in the system can increase the amount of delay that can be tolerated before the onset of instability. The delay problem is formulated in the discrete time domain and an analysis procedure suggested. The maximum principle from optimal control theory is applied to minimize the time required for the slewing of a general rigid spacecraft. The slewing motion need not be restricted to a single axis maneuver. The minimum slewing time is calculated based on a quasi-linearization algorithm for the resulting two point boundary value problem. Numerical examples based on the rigidized in-orbit model of the SCOLE also include the more general reflector line-of-sight slewing maneuvers. Author

N87-29162*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
USER INTERFACE AND PAYLOAD COMMAND AND CONTROL

In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 10 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Two tasks comprise this overall effort. The first is concerned with developing a modular, machine independent workstation design, science operations interface language and interaction techniques. Design concepts and prototype demonstration of a state of the art prototype workstation are to be based on defining user requirements by determining user interface modes, reflecting needs in space and on ground. The second task aims at generating a command and control system design concept for supporting telescience - a concept for independent science user operations within an operations envelope. Author

N87-29713*# Catholic Univ. of America, Washington, D.C. Dept. of Mechanical Engineering.
EFFECT OF BONDING ON THE PERFORMANCE OF A PIEZOACTUATOR-BASED ACTIVE CONTROL SYSTEM
A. BAZ and S. POH 28 Oct. 1987 36 p
(Contract NAG5-520; NAG5-749)
(NASA-CR-181414; NAS 1.26:181414) Avail: NTIS HC A03/MF A01 CSCL 13H

The utilization of piezoelectric actuators in controlling the structural vibrations of flexible beams is studied. A Modified Independent Modal Space Control (MIMSC) method is devised to select the optimal location, control gains and excitation voltage of the piezoelectric actuators in a way that would minimize the amplitudes of vibrations of beams to which these actuators are bonded, as well as the input control energy necessary to suppress these vibrations. The presented method accounts for the effects that the piezoelectric actuators and the bonding layers have on changing the elastic and inertial properties of the flexible beams. Numerical examples are presented to illustrate the application of the MIMSC method and to demonstrate the effect of the physical and geometrical properties of the bonding layer on the dynamic performance of the actively controlled beams. The obtained results emphasize the importance of the devised method in designing more realistic active control systems for flexible beams, in particular, and large flexible structures in general. Author

N87-29933*# Oak Ridge National Lab., Tenn.
APPLICATION OF ADVANCED FLYWHEEL TECHNOLOGY FOR ENERGY STORAGE ON SPACE STATION
MITCHELL OLSZEWSKI *In* NASA-Lewis Research Center, Space Electrochemical Research and Technology (SERT) p 147-156 Sep. 1987 Previously announced as N87-24029
(Contract DE-AC05-84OR-21400)
Avail: NTIS HC A16/MF A01 CSCL 10C

In space power applications where solar inputs are the primary thermal source, energy storage is necessary to provide a continuous power supply during the eclipse portion of the orbit. Because of their potentially high storage density, flywheels are being considered for use as the storage system on the proposed orbiting space station. During the past several years, graphite fiber technology has advanced, leading to significant gains in flywheel storage density. Use of these improved fibers in experimental flywheel rims has resulted in ultimate storage densities of 878 kJ/kg. With these high strength graphite fibers, operational storage densities for flywheel storage modules applicable to the space station power storage could reach 200 kJ/kg. This module would also be volumetrically efficient occupying only about 1 cu m. Because the size and mass of the flywheel storage module are controlled by the storage density, improvements in fiber strength can have a significant impact on these values. With the improvements anticipated within the next five years, operational storage density on the order of 325 kJ/kg may be possible for the flywheel module. Author

07

POWER

Includes descriptions of analyses, systems, and trade studies of electric power generation, storage, conditioning and distribution.

A87-32308
A TWO-DIMENSIONAL NUMERICAL HEAT TRANSFER MODEL FOR A SOLAR PROPULSION SYSTEM
D. P. MILLER and J. R. OSBORN (Purdue University, West Lafayette, IN) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 231-236. refs

A two-dimensional numerical heat transfer model which considered the interaction of conduction, convection and radiation transport mechanisms, was developed for the investigation of the design of an advanced solar thruster. Radiation effects included the scattering, absorption and emissive characteristics of the particle bed. The governing equations were solved using an implicit finite difference method of solution. The flow and temperature distributions are shown computed in the solar absorption chamber. The performance was computed from the temperature distributions and comparisons shown between the present analysis and one-dimensional results. The efficiency of the absorber was predicted for various geometric considerations and compared to the one-dimensional predictions. Results are summarized for a range of parameters. Author

A87-32578
POWER MANAGEMENT EQUIPMENT FOR SPACE APPLICATIONS
W. W. BILLINGS, D. A. FOX, and R. G. WAGONER (Westinghouse Electric Corp., Electrical Systems Div., Lima, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 12 p.
(SAE PAPER 861621)

The electric power management system on the Space Station will require a complete spectrum of switchgear, power controllers, remote controlled circuit breakers, and conversion equipment. This paper describes some of the AC and DC equipment currently being developed for potential Space Station application. The AC equipment includes High Power Switchgear with 12 switches rated at 440 Vac, 34 Amps; Remote Power Controllers with 2 poles rated at 115 Vac, 43 Amps; three phase Remote Controlled Circuit Breakers rated at 440 Vac, 43 Amps; and a Remote Controlled Switch rated at 115 Vac, 50 Amps. The DC equipment includes a two pole Remote Power Controller rated at 150 Vdc, 40 Amps and a Remote Controlled Circuit Breaker rated at 150 Vdc, 33 Amps. The conversion equipment consists of a 25 kW, 150 Vdc to 440 Vac converter. Distribution equipment being developed includes a 15 kW, 440 Vac to 115 Vac Isolation Transformer and a 5 kW, 440 Vac to 150 Vdc TR Unit. Most of this equipment is designed to allow connection to a Power System Controller through a MIL-STD-1553B Data Bus. The Data Bus provides a pathway for control and status data to and from the equipment and allows reporting of system loads and voltages via built-in monitoring circuits. Author

A87-32579
AN INTEGRATED ANALYTIC TOOL AND KNOWLEDGE-BASED SYSTEM APPROACH TO AEROSPACE ELECTRIC POWER SYSTEM CONTROL
WILLIAM R. OWENS, ERIC HENDERSON, and KAPAL GANDIKOTA (Sundstrand Corp., Rockford, IL) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p. refs
(SAE PAPER 861622)

Future aerospace electric power systems require new control methods because of increasing power system complexity, demands for power system management, greater system size and heightened reliability requirements. To meet these requirements, a combination of electric power system analytic tools and knowledge-based systems is proposed. The continual improvement in microelectronic performance has made it possible to envision the application of sophisticated electric power system analysis tools to aerospace vehicles. These tools have been successfully used in the measurement and control of large terrestrial electric power systems. Among these tools is state estimation which has three main benefits. The estimator builds a reliable database for the system structure and states. Security assessment and contingency evaluation also require a state estimator. Finally, the estimator will, combined with modern control theory, improve power system control and stability. Bad data detection as an adjunct to state estimation identifies defective sensors and communications channels. Validated data from the analytic tools is supplied to a number of knowledge-based systems. These systems will be responsible for the control, protection, and optimization of the electric power system. Author

A87-32747* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SOLAR ARRAY FLIGHT DYNAMIC EXPERIMENT

RICHARD W. SCHOCK (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 351-365. Previously announced in STAR as N87-12581.
(AAS PAPER 86-050)

The purpose of the Solar Array Flight Dynamic Experiment (SAFDE) is to demonstrate the feasibility of on-orbit measurement and ground processing of large space structures dynamic characteristics. Test definition or verification provides the dynamic characteristic accuracy required for control systems use. An illumination/measurement system was developed to fly on Space Shuttle flight STS-31D. The system was designed to dynamically evaluate a large solar array called the Solar Array Flight Experiment (SAFE) that had been scheduled for this flight. The SAFDE system consisted of a set of laser diode illuminators, retroreflective targets, an intelligent star tracker receiver and the associated equipment to power, condition, and record the results. In six tests on STS-41D, data was successfully acquired from 18 retroreflector targets and ground processed, post flight, to define the solar array's dynamic characteristic. The flight experiment proved the viability of on-orbit test definition of large space structures dynamic characteristics. Future large space structures controllability should be greatly enhanced by this capability. Author

A87-33787* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ADVANCED TECHNOLOGY FOR EXTENDED ENDURANCE ALKALINE FUEL CELLS

D. W. SHEIBLEY (NASA, Lewis Research Center, Cleveland, OH) and R. A. MARTIN (International Fuel Cells Corp., South Windsor, CT) IN: Progress in batteries and solar cells. Volume 6 . Cleveland, OH, JEC Press, Inc., 1987, p. 155-156.

Advanced components have been developed for alkaline fuel cells with a view to the satisfaction of NASA Space Station design requirements for extended endurance. The components include a platinum-on-carbon catalyst anode, a potassium titanate-bonded electrolyte matrix, a lightweight graphite electrolyte reservoir plate, a gold-plated nickel-perforated foil electrode substrate, a polyphenylene sulfide cell edge frame material, and a nonmagnesium cooler concept. When incorporated into the alkaline fuel cell unit, these components are expected to yield regenerative operation in a low earth orbit Space Station with a design life greater than 5 years. O.C.

A87-35799

THE SYNTHESIS OF THE POWER TRANSMISSION CHANNEL FOR A SATELLITE SOLAR POWER STATION [K VOPROSU O SINTEZE TRAKTA PEREDACHI ENERGII SOLNECHNOI KOSMICHESKOI ELEKTROSTANTSII /SKES/]

V. A. VANKE, S. K. LESOMA, and A. V. RACHNIKOV Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 32, March 1987, p. 655-657. In Russian. refs

The problem of sidelobe reduction for the microwave power transmission channel of a satellite solar power station is considered. Discrete amplitude distributions of electric field strength with respect to the radius of the transmitting antenna are plotted which provide for sidelobe levels not greater than 0.13 microW/sq cm and not greater than 5 microW/sq cm. It is shown that the sidelobe level can be reduced to below the EMC standard in the case of amplitude and radius fluctuations of the discrete amplitude distribution with a normalized rms error not exceeding 1 percent and a rms phase error not exceeding 0.5. B.J.

A87-36913*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE STATION 20-KHZ POWER MANAGEMENT AND DISTRIBUTION SYSTEM

IRVING G. HANSEN and GALE R. SUNDBERG (NASA Lewis Research Center, Cleveland, OH) IN: PESC '86; Annual Power Electronics Specialists Conference, 17th, Vancouver, Canada, June 23-27, 1986, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 676-683. Previously announced in STAR as N86-24747. refs

During the conceptual design phase a 20-kHz power distribution system was selected as the reference for the Space Station. The system is single-phase 400 VRMS, with a sinusoidal wave form. The initial user power level will be 75 kW with growth to 300 kW. The high-frequency system selection was based upon considerations of efficiency, weight, safety, ease of control, interface with computers, and ease of paralleling for growth. Each of these aspects will be discussed as well as the associated trade-offs involved. An advanced development program has been instituted to accelerate the maturation of the high-frequency system. Some technical aspects of the advanced development will be discussed. Author

A87-36944

ERATO ORBITAL TRANSFER VEHICLE WITH ELECTRONUCLEAR POWER STUDY OF THE ASSOCIATED ELECTRONUCLEAR GENERATOR [REMORQUEUR ELECTRONUCLEAIRE SPATIAL ERATO - ETUDE DU GENERATEUR ELECTRONUCLEAIRE ASSOCIE]

CLAUDE POHER (CNES, Paris, France) and JEAN DELAPLACE (CEA, Paris, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 120, 1986, p. 58-61. In French.

Characteristics of the several-hundred-kilowatt electronuclear generator projected for the ERATO orbital transfer vehicle (OTV) for the period past 2005 are discussed. It is suggested that such generators will be 2-3 times lighter than solar generators of comparable power, and that the ERATO OTV will be capable of transferring heavy payloads from a low orbit to a geostationary orbit at a much lower cost than possible with the usual chemical processes. The projected electronuclear generators will be sufficiently protected for military space applications, and their development will require the usage of high-temperature (1200 C) material technologies. R.R.

A87-37291*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

MANNED SPACECRAFT ELECTRICAL POWER SYSTEMS

WILLIAM E. SIMON (NASA, Johnson Space Center, Houston, TX) and DONALD L. NORED (NASA, Lewis Research Center, Cleveland, OH) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 277-307. refs

A brief history of the development of electrical power systems from the earliest manned space flights illustrates a natural trend toward a growth of electrical power requirements and operational lifetimes with each succeeding space program. A review of the design philosophy and development experience associated with the Space Shuttle Orbiter electrical power system is presented, beginning with the state of technology at the conclusion of the Apollo Program. A discussion of prototype, verification, and

qualification hardware is included, and several design improvements following the first Orbiter flight are described. The problems encountered, the scientific and engineering approaches used to meet the technological challenges, and the results obtained are stressed. Major technology barriers and their solutions are discussed, and a brief Orbiter flight experience summary of early Space Shuttle missions is included. A description of projected Space Station power requirements and candidate system concepts which could satisfy these anticipated needs is presented. Significant challenges different from Space Shuttle, innovative concepts and ideas, and station growth considerations are discussed. The Phase B Advanced Development hardware program is summarized and a status of Phase B preliminary tradeoff studies is presented.
Author

A87-39628#

DEVELOPMENT OF THE ELECTRICAL POWER SUBSYSTEM FOR THE ELECTRIC PROPULSION EXPERIMENT ONBOARD THE SPACE FLYER UNIT (SFU)

Y. KUNII, T. MORIAI, H. SASAKI, T. OKAMURA, H. HARADA (Mitsubishi Electric Corp., Kamakura, Japan) et al. AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 8 p. refs
(AIAA PAPER 87-1040)

Bread Board Model of a few kW class electrical power subsystem is being developed for the Electric Propulsion Experiment (EPEX), which is a space experiment program for a quasi-steady MPD thruster system. EPEX is planned to be tested on a Japanese free flying platform, which is planned to be operational in the 1990s. A one-million-cycle endurance test was carried out from December 1985 to January 1986 with a 1-kW-class pulse forming network (PFN) using improved plastic film capacitors of reduced weight. The test was accomplished in a vacuum chamber with arc discharges. The BBM PFN was designed and manufactured with the results of the one-million-cycle endurance test, and a ten-million cycle endurance test is planned starting October 1987.
Author

A87-39629#

DEVELOPMENT OF CONTROL AND MONITOR SUBSYSTEM FOR ELECTRIC PROPULSION EXPERIMENT ONBOARD SPACE FLYER UNIT (SFU)

Y. KUNII, T. MORIAI, T. OKAMURA, T. YOSHIDA, K. UICHI (Mitsubishi Electric Corp., Kamakura, Japan) et al. AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 6 p.
(AIAA PAPER 87-1041)

The Electric Propulsion Experiment (EPEX) is a Japanese space experiment program for the quasi-steady MPD thruster system. The EPEX is planned to be tested on a Japanese free flying platform and launched in the 1990s. The requirements for the control and monitor subsystem of EPEX were discussed and the conceptual design was performed. Since 1983, repetitive charging and discharging operations for the ground endurance tests were conducted with the sequence controllers, which were made of hard wired logic circuits. Photo transistors were found to be preferable for recognition of the occurence of arc discharge and the normal termination of the repetitive cycle. For the EPEX, because of the limited capability of the platform bus system, the autonomous operation of the experiment is required in addition to the simple sequence control. The autonomous operation with a microcomputer system will be tested in the next ground endurance test to be started in October 1987.
Author

A87-39735

PERMANENT-MAGNET LINEAR ALTERNATORS. I - FUNDAMENTAL EQUATIONS. II - DESIGN GUIDELINES

I. BOLDEA (Institutul Politehnic, Timisoara, Rumania) and S. A. NASAR (Kentucky, University, Lexington) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, Jan. 1987, p. 73-82. refs
(Contract NSF ECS-83-14238; NSF INT-84-08315)

The general equations of permanent-magnet heteropolar three-phase and single-phase linear alternators, powered by free-piston Stirling engines, are presented, with application to space power stations and domestic applications including solar power plants. The equations are applied to no-load and short-circuit conditions, illustrating the end-effect caused by the speed-reversal process. In the second part, basic design guidelines for a three-phase tubular linear alternator are given, and the procedure is demonstrated with the numerical example of the design of a 25-kVA, 14.4-m/s, 120/220-V, 60-Hz alternator.
R.R.

A87-40378*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

20 KHZ SPACE STATION POWER SYSTEM

IRVING G. HANSEN and FREDRICK J. WOLFF (NASA, Lewis Research Center, Cleveland, OH) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 251-255. Previously announced in STAR as N86-28122. refs

The Space Station represents the next major U.S. commitment in space. The efficient delivery of power to multiple user loads is key to that success. In 1968, NASA Lewis Research Center began a series of studies with component and circuit developments that led to the high frequency bi-directional, four quadrant resonant driven converter. Additional studies and subsequent developments into the early 1980's have shown how the high frequency ac power system could provide overall advantages to many aerospace power systems. Because of its wide versatility, it also has outstanding advantages for the Space Station Program and its wide range of users. High frequency ac power provides higher efficiency, lower cost, and improved safety. The 20 kHz power system has exceptional flexibility, is inherently user friendly, and is compatible with all types of energy sources - photovoltaic, solar dynamic, rotating machines or nuclear Lewis distribution system testbed. The testbed demonstrates flexibility, versatility, and transparency to user technology as well as high efficiency, low mass, and reduced volume.
Author

A87-41145*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NUCLEAR REACTOR POWER FOR AN ELECTRICALLY POWERED ORBITAL TRANSFER VEHICLE

L. JAFFE, R. BEATTY, P. BHANDARI, E. CHOW, W. DEININGER, R. EWELL, T. FUJITA, M. GROSSMAN, T. KIA, B. NESMITH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) et al. AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 7 p. DOD-DOE-NASA-sponsored research.
(AIAA PAPER 87-1102)

To help determine the systems requirements for a 300-kWe space nuclear reactor power system, a mission and spacecraft have been examined which utilize electric propulsion and this nuclear reactor power for multiple transfers of cargo between low earth orbit (LEO) and geosynchronous earth orbit (GEO). A propulsion system employing ion thrusters and xenon propellant was selected. Propellant and thrusters are replaced after each sortie to GEO. The mass of the Orbital Transfer Vehicle (OTV), empty and dry, is 11,000 kg; nominal propellant load is 5000 kg. The OTV operates between a circular orbit at 925 km altitude, 28.5 deg inclination, and GEO. Cargo is brought to the OTV by Shuttle and an Orbital Maneuvering Vehicle (OMV); the OTV then takes it to GEO. The OTV can also bring cargo back from GEO, for transfer by OMV to the Shuttle. OTV propellant is resupplied and the ion thrusters are replaced by the OMV before each trip to GEO. At the end of mission life, the OTV's electric propulsion is used to place it in a heliocentric orbit so that the reactor will not return to earth. The nominal cargo capability to GEO is 6000 kg with a transit time of 120 days; 1350 kg can be transferred in 90 days, and 14,300 kg in 240 days. These capabilities can be considerably increased by using separate Shuttle launches to bring up propellant and cargo, or by changing to mercury propellant.
Author

A87-42265#

SURVEY OF SOLAR-DYNAMIC SPACE POWER - THE STIRLING OPTION

D. ESHUIS (Delft, Technische Hogeschool, Netherlands) ESA Journal (ISSN 0379-2285), vol. 10, no. 4, 1986, p. 343-362. refs

An assessment of the feasibility and implications of a Stirling-cycle space power system is described by looking at various aspects of the system, its subsystems and components, and a reference configuration for preliminary calculations and comparisons is presented. Among the technologies applied would be those of: free-piston Stirling engines, inflatable space-rigidized structures, heat-pipes, and thermal energy storage. It can be concluded that Solar-Dynamic Space Power System development still has a long way to go, but that an increased R&D effort is warranted by the good prospects that the technology shows.
Author

A87-43004#

A TRANSIENT ANALYSIS OF PHASE CHANGE ENERGY STORAGE SYSTEM FOR SOLAR DYNAMIC POWER

D. K. DAROOKA (General Electric Co., Space Div., Philadelphia, PA) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 12 p.
(AIAA PAPER 87-1469)

The Phase Change Energy Storage System constitutes a key element of the Solar Dynamic Power System now being considered for the Space Station. The stored energy is provided to the Energy Conversion System during the non-illuminated portion of the orbit. This cyclic nature of the application requires understanding of the transient behavior of the Energy Storage System. A one dimensional thermal model was developed that uses a fixed-grid, implicit finite-difference formulation to handle the transient interface condition between the liquid and solid phases. This model was applied to a conceptual design of solar thermal receiver based on radiative coupling between the thermal energy storage container and the heat exchanger for the working fluid. Transient results indicate that the proposed design concept can meet the Space Station requirements. Author

A87-45363#

PERFORMANCE OF AN SP-100/PULSED ELECTROTHERMAL THRUSTER ORBIT TRANSFER VEHICLE

R. L. BURTON (GT-Devices, Inc., Alexandria, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 6 p. refs
(AIAA PAPER 87-2027)

The performance of the pulsed electrothermal (PET) thruster is evaluated for SP-100-based orbit transfer missions at the 100 kWe level. The PET thruster is a high resistance, high pressure electrothermal discharge coupled to a supersonic, equilibrium flow nozzle. The discharge, which pulses at over 100 Hz, is designed so as to prevent ablation of the thruster components. The thruster efficiency is predicted to be 70 percent using hydrazine propellant at a 1030-second specific impulse and a thrust/power ratio of 0.14 N/kW. System component masses are presented for orbit transfer missions of Delta V = 6 km/s and 1 km/s. System lifetime is discussed for these missions. Liquid hydrogen performance is 78 percent at 2500 seconds for the PET thruster, for missions where cryogenics can be accommodated. Author

A87-48264

NEW POWER PROCESSOR INTERFACES MMS POWER MODULE OUTPUTS

P. R. K. CHETTY (Fairchild Space Co., Germantown, MD) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, May 1987, p. 311-316.

A description of a new power processor to interface the outputs from two or more multimission modular spacecraft (MMS) modular power system (MPS) modules to the spacecraft payload is presented. Also included are an introduction describing the circumstances that led to this power processor, and material concerning analysis results, load programmability, and salient features, including efficiency and weight aspects. Finally, important input and output electrical characteristics of this processor are summarized. Author

A87-50511#

A COMPARISON OF SCHEDULING ALGORITHMS FOR AUTONOMOUS MANAGEMENT OF THE SPACE STATION ELECTRIC ENERGY SYSTEM

DOUGLAS BERMAN and JOHN W. MCCLURE (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1007-1016. refs
(AIAA PAPER 87-2467)

The scheduling problem associated with the onboard, autonomous management of the Space Station electric energy system, and two solution approaches developed at Draper Laboratory, are examined. The scheduling problem is posed as a constrained combinatorial optimization problem. This formulation takes into account the dynamics and limitations posed by the power generation and storage systems, the various power profiles for the tasks to be scheduled, as well as the different optimization criteria defining desirable schedules. Given this problem definition, solution approaches based on the now popular simulated annealing algorithm and on a multistart algorithm are proposed and contrasted. Following the description of these approaches, experience with these approaches is summarized in a results section. Author

N87-20584*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SAFE/DAE: MODAL TEST IN SPACE

T. E. NESMAN and D. K. REED *In* Shock and Vibration Information Center The Shock and Vibration Bulletin. Part 2: Modal Test and Analysis, Testing Techniques, Machinery Dynamics, Isolation and Damping, Structural Dynamics p 29-36 Aug. 1986
Avail: NTIS HC A10/MF A01 CSCL 22B

In September of 1984, NASA performed a series of experiments on orbit with a large solar wing attached to the Space Shuttle orbiter. These experiments, the Solar Array Flight Experiment (SAFE), mark the first tests of a large space structure in space. Extension, retraction, and dynamic tests had to be performed in space due to the fragility of the solar array. Due to the extendable and retractable design of the solar array, accelerometers and associated wires could not be used; therefore, remote sensing, the Dynamics Augmentation Experiment (DAE), was added to the SAFE program. The DAE uses a remote sensor based on star tracker technology to measure the dynamic response of the solar array. The DAE sensor tracked 18 targets on the solar array during free-decay response to a transient excitation. An overview of the SAFE/DAE is presented, highlighting analysis results from the remotely sensed data. Modal parameter estimates from the remotely sensed data were computed using the complex exponential and polyreference techniques. Author

N87-21153*# Sverdrup Technology, Inc., Middleburg Heights, Ohio.

MICROGRAVITY FLUID MANAGEMENT REQUIREMENTS OF ADVANCED SOLAR DYNAMIC POWER SYSTEMS

ROBERT P. MIGRA *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 151-162 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

The advanced solar dynamic system (ASDS) program is aimed at developing the technology for highly efficient, lightweight space power systems. The approach is to evaluate Stirling, Brayton and liquid metal Rankine power conversion systems (PCS) over the temperature range of 1025 to 1400K, identify the critical technologies and develop these technologies. Microgravity fluid management technology is required in several areas of this program, namely, thermal energy storage (TES), heat pipe applications and liquid metal, two phase flow Rankine systems. Utilization of the heat of fusion of phase change materials offers potential for smaller, lighter TES systems. The candidate TES

materials exhibit large volume change with the phase change. The heat pipe is an energy dense heat transfer device. A high temperature application may transfer heat from the solar receiver to the PCS working fluid and/or TES. A low temperature application may transfer waste heat from the PCS to the radiator. The liquid metal Rankine PCS requires management of the boiling/condensing process typical of two phase flow systems.
Author

N87-22004*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EMC AND POWER QUALITY STANDARDS FOR 20-KHZ POWER DISTRIBUTION
IRVING G. HANSEN 1987 8 p Proposed for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa., 10-14 Aug. 1987; sponsored by AIAA, ANS, ASME, SAE, IEEE, ACS and AIChE
(NASA-TM-89925; E-3626; NAS 1.15:89925; AIAA-87-9355)
Avail: NTIS HC A02/MF A01 CSCL 09C

The Space Station Power Distribution System has been baselined as a sinusoidal single phase, 440 VRMS system. This system has certain unique characteristics directly affecting its application. In particular, existing systematic description and control documents were modified to reflect the high operating frequency. This paper will discuss amendments made on Mil STD 704 (Electrical Power Characteristics), and Mil STD 461-B (Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference). In some cases these amendments reflect changes of several orders of magnitude. Implications and impacts of these changes are discussed.
Author

N87-22174*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELECTION OF HIGH TEMPERATURE THERMAL ENERGY STORAGE MATERIALS FOR ADVANCED SOLAR DYNAMIC SPACE POWER SYSTEMS
DOVIE E. LACY, CAROLYN COLES-HAMILTON, and ALBERT JUHASZ 1987 13 p Proposed for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa., 10-14 Aug. 1987; sponsored by AIAA, ANS, ASME, SAE, IEEE, ACS and AIChE
(NASA-TM-89886; E-3569; NAS 1.15:89886) Avail: NTIS HC A02/MF A01 CSCL 10B

Under the direction of NASA's Office of Aeronautics and Technology (OAST), the NASA Lewis Research Center has initiated an in-house thermal energy storage program to identify combinations of phase change thermal energy storage media for use with a Brayton and Stirling Advanced Solar Dynamic (ASD) space power system operating between 1070 and 1400 K. A study has been initiated to determine suitable combinations of thermal energy storage (TES) phase change materials (PCM) that result in the smallest and lightest weight ASD power system possible. To date the heats of fusion of several fluoride salt mixtures with melting points greater than 1025 K have been verified experimentally. The study has indicated that these salt systems produce large ASD systems because of their inherent low thermal conductivity and low density. It is desirable to have PCMs with high densities and high thermal conductivities. Therefore, alternate phase change materials based on metallic alloy systems are also being considered as possible TES candidates for future ASD space power systems.
Author

N87-22722*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY FLIGHT DYNAMIC EXPERIMENT
RICHARD W. SCHOCK *In its* Structural Dynamics and Control Interaction of Flexible Structures p 487-504 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 10A

The purpose of the Solar Array Flight Dynamic Experiment (SAFDE) is to demonstrate the feasibility of on-orbit measurement and ground processing of large space structures' dynamic characteristics. Test definition or verification provides the dynamic characteristic accuracy required for control systems use. An illumination/measurement system was developed to fly on space shuttle flight STS-41D. The system was designed to dynamically evaluate a large solar array called the Solar Array Flight Experiment (SAFE) that had been scheduled for this flight. The SAFDE system consisted of a set of laser diode illuminators, retroreflective targets, an intelligent star tracker receiver and the associated equipment to power, condition, and record the results. In six tests on STS-41D, data was successfully acquired from 18 retroreflector targets and ground processed, post flight, to define the solar array's dynamic characteristic. The flight experiment proved the viability of on-orbit test definition of large space structures dynamic characteristics. Future large space structures controllability should be greatly enhanced by this capability.
Author

N87-22740*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SLEWING CONTROL EXPERIMENT FOR A FLEXIBLE PANEL
JER-NAN JUANG *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1013-1032 Apr. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

Technology areas are identified in which better analytical and/or experimental methods are needed to adequately and accurately control the dynamic responses of multibody space platforms such as the space station. A generic space station solar panel is used to experimentally evaluate current control technologies. Active suppression of solar panel vibrations induced by large angle maneuvers is studied with a torque actuator at the root of the solar panel. These active suppression tests will identify the hardware requirements and adequacy of various controller designs.
Author

N87-23028*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE CHARACTERISTICS OF A COMBINATION SOLAR PHOTOVOLTAIC HEAT ENGINE ENERGY CONVERTER
DONALD L. CHUBB 1987 14 p Prepared for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa. 10-14 Aug. 1987; cosponsored by AIAA, ANS, ASME, SAE, IEEE, ACS, AIChE
(NASA-TM-89908; E-3591; NAS 1.15:89908; AIAA-87-9035)
Avail: NTIS HC A02/MF A01 CSCL 10A

A combination solar photovoltaic heat engine converter is proposed. Such a system is suitable for either terrestrial or space power applications. The combination system has a higher efficiency than either the photovoltaic array or the heat engine alone can attain. Advantages in concentrator and radiator area and receiver mass of the photovoltaic heat engine system over a heat-engine-only system are estimated. A mass and area comparison between the proposed space station organic Rankine power system and a combination PV-heat engine system is made. The critical problem for the proposed converter is the necessity for high temperature photovoltaic array operation. Estimates of the required photovoltaic temperature are presented.
Author

N87-23095*# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.
SPACE STATION WP-04 POWER SYSTEM. VOLUME 1: EXECUTIVE SUMMARY Final Study Report
G. J. HALLINAN 19 Jan. 1987 92 p
(Contract NAS3-24666)
(NASA-CR-179587-VOL-1; NAS 1.26:179587-VOL-1; FSR-DR-15-VOL-1) Avail: NTIS HC A05/MF A01 CSCL 14B

Major study activities and results of the phase B study contract for the preliminary design of the space station Electrical Power System (EPS) are summarized. The areas addressed include the general system design, man-tended option, automation and robotics, evolutionary growth, software development environment, advanced development, customer accommodations, operations planning, product assurance, and design and development phase planning. The EPS consists of a combination photovoltaic and solar dynamic power generation subsystem and a power management and distribution (PMAD) subsystem. System trade studies and costing activities are also summarized. M.G.

N87-23696*# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.
SPACE STATION WP-04 POWER SYSTEM. VOLUME 2: STUDY RESULTS Final Study Report
G. J. HALLINAN 19 Jan. 1987 556 p
(Contract NAS3-24666)
(NASA-CR-179587-VOL-2; NAS 1.26:179587-VOL-2; FSR-DR-15-VOL-2) Avail: NTIS HC A24/MF A01 CSCL 14B

Results of the phase B study contract for the definition of the space station Electric Power System (EPS) are presented in detail along with backup information and supporting data. Systems analysis and trades, preliminary design, advanced development, customer accommodations, operations planning, product assurance, and design and development phase planning are addressed. The station design is a hybrid approach which provides user power of 25 kWe from the photovoltaic subsystem and 50 kWe from the solar dynamic subsystem. The electric power is distributed to users as a utility service; single phase at a frequency of 20 kHz and voltage of 440VAC. The solar array NiH2 batteries of the photovoltaic subsystem are based on commonality to those used on the co-orbiting and solar platforms. M.G.

N87-24530# Alcatel Thomson Espace, Toulouse (France).
ASSESSMENT OF SPACE STATION POWER SYSTEM Final Report
Paris, France ESA Oct. 1986 210 p
(Contract ESA-5170/85-NL-AN(SC))
(ATES-AN-86/466; ESA-CR(P)-2355; ETN-87-99689) Avail: NTIS HC A10/MF A01

It is shown that for large power spacecraft exceeding 10 KW user power, the distributed voltage must be a trade-off between mass of power system elements, transmission efficiency, plasma losses, component technology availability, and safety. The optimum voltage is 150 V. Simulation results indicate that the best electrical, mechanical, and thermal performances are available with an unregulated bus power system and the worst ones with the regulated bus concept, the sunlight regulated bus system data being very close to the latter concept. The substandard performance of the regulated bus voltage configuration is explainable by the fact that the simulation software is restricted to the power system platform simulation and does not take into account the important part of the active power distribution (voltage regulators on every user network) which is hidden in the user power profile. In spite of the contradictory results of the configuration evaluation, the regulated bus concept is advocated as power system configuration for the Space Station at 150 V + or - 10%. ESA

N87-24532# Technische Univ., Berlin (West Germany). Inst. fuer Luft- und Raumfahrt.
PRELIMINARY ANALYSIS OF A PROTOTYPE SPACE SOLAR POWER SYSTEM
BERND JOHENNING, HEINZ-HERMANN KOELLE, THOMAS ALTMANN, THOMAS DREER, THOMAS ECKARDT, ANDREAS JAIN, OLAF KERINNIS, MICHAEL KRUEGER, MICHAEL MIELKE, and NICOLAUS MILLIN 15 Oct. 1986 35 p In GERMAN; ENGLISH summary
(ILR-MITT-168; ETN-87-99672) Avail: NTIS HC A03/MF A01

The results of a study project on a 500MW space solar power unit are summarized. The analysis concentrated on the assembly process to be carried out in geostationary orbit. The satellite power unit and the required infrastructure (manufacturing plant, habitat, space port, space tugs, etc.) have a total mass of 10,000 metric tons. It is estimated that the assembly of this complex takes 40 months at an average crew of 40 at the assembly site. The logistics support requires 134 flights of a space freighter with a payload of 100 metric tons, and 29 passenger flights. The transition from prototype assembly to large scale manufacturing is discussed. ESA

N87-24533# Technische Hogeschool, Delft (Netherlands). Dept. of Electrical Engineering.
STATUS OF SERIES-RESONANT POWER CONVERSION WITH HIGH INTERNAL FREQUENCIES. SUPPORT IN DEFINITION OF SPACE STATION POWER INTERFACE
J. BENKLAASSENS and JEROEN VANDUIVENBODE Paris, France ESA 1986 99 p
(Contract ESA-5170/85-NL-AN(SC))
(ESA-CR(P)-2319; ETN-87-99675) Avail: NTIS HC A05/MF A01

The principles of series-resonant power conversion are reviewed. Optimization of series-resonant converters is discussed. The role the series-resonant converter can play in the power system of the Columbus space station is assessed. Its implementation conversion gives dc conversion practically all the advantages of ac conversion, due to the fact that the series-resonant conversion process is based on the transfer of electric energy by an ac internal waveform. ESA

N87-24836*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF COMPONENT COMPRESSION ON THE INITIAL PERFORMANCE OF AN IPV NICKEL-HYDROGEN CELL
RANDALL F. GAHN 1987 17 p Prepared for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa., 10-14 Aug. 1987; cosponsored by AIAA, ANS, ASME, SAE, IEEE, ACS, and AIChE
(NASA-TM-100102; E-3590; NAS 1.15:100102; AIAA-87-9257) Avail: NTIS HC A02/MF A01 CSCL 10C

An experimental method was developed for evaluating the effect of component compression on the charge and discharge voltage characteristics of a 3 1/2 in. diameter boiler plate cell. A standard boiler plate pressure vessel was modified by the addition of a mechanical feedthrough on the bottom of the vessel which permitted different compressions to be applied to the components without disturbing the integrity of the stack. Compression loadings from 0.94 to 27.4 psi were applied by suspending weights from the feedthrough rod. Cell voltages were measured for 0.96-C, 55-min charge and for 1.37-C, 35-min and 2-C, 24-min discharges. An initial change in voltage performance on both charge and discharge as the loading increased was attributed to seating of the components. Subsequent variation of the compression from 2.97 to 27.4 psi caused only minor changes in either the charge or the discharge voltages. Several one month open-circuit voltage stands and 1100 cycles under LEO conditions at the maximum loading have produced no change in performance. Author

N87-25836*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUCLEAR REACTOR POWER FOR A SPACE-BASED RADAR. SP-100 PROJECT
HARVEY BLOOMFIELD, JACK HELLER, LEONARD JAFFE, RICHARD BEATTY, PRADEEP BHANDARI, EDWIN CHOW, WILLIAM DEININGER, RICHARD EWELL, TOSHIO FUJITA, MERLIN GROSSMAN et al. 31 Aug. 1986 176 p Prepared in cooperation with JPL, Pasadena, Calif. and Los Alamos National Lab., N. Mex.
(Contract NAS7-918; DE-AI03-86SF-16013)
(NASA-TM-89295; JPL-PUB-86-47; NAS 1.15:89295) Avail: NTIS HC A09/MF A01 CSCL 18I

A space-based radar mission and spacecraft, using a 300 kWe nuclear reactor power system, has been examined, with emphasis on aspects affecting the power system. The radar antenna is a horizontal planar array, 32 X 64 m. The orbit is at 61 deg, 1088 km. The mass of the antenna with support structure is 42,000 kg; of the nuclear reactor power system, 8,300 kg; of the whole spacecraft about 51,000 kg, necessitating multiple launches and orbital assembly. The assembly orbit is at 57 deg, 400 km, high enough to provide the orbital lifetime needed for orbital assembly. The selected scenario uses six Shuttle launches to bring the spacecraft and a Centaur G upper-stage vehicle to assembly orbit. After assembly, the Centaur places the spacecraft in operational orbit, where it is deployed on radio command, the power system started, and the spacecraft becomes operational. Electric propulsion is an alternative and allows deployment in assembly orbit, but introduces a question of nuclear safety. Author

N87-26144*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE STATION ELECTRICAL POWER SYSTEM

THOMAS L. LABUS and THOMAS H. COCHRAN 1987 19 p
Proposed for presentation at the 38th International Astronautical Federation Congress, Brighton, England, 10-17 Oct. 1987
(NASA-TM-100140; E-3692; NAS 1.15:100140; IAF-87-234)
Avail: NTIS HC A02/MF A01 CSCL 22B

The purpose of this paper is to describe the design of the Space Station Electrical Power System. This includes the Photovoltaic and Solar Dynamic Power Modules as well as the Power Management and Distribution System (PMAD). In addition, two programmatic options for developing the Electrical Power System will be presented. One approach is defined as the Enhanced Configuration and represents the results of the Phase B studies conducted by the NASA Lewis Research Center over the last two years. Another option, the Phased Program, represents a more measured approach to reaching about the same capability as the Enhanced Configuration. Author

N87-26414*# National Aeronautics and Space Administration, Washington, D.C.

AN OVERVIEW OF PHOTOVOLTAIC APPLICATIONS IN SPACE

ROBERT A. WASEL *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology 1986. High Efficiency, Space Environment and Array Technology p 1-7 Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 10B

An overview is given of the uses of photovoltaic (PV) power in space. The contribution of PV systems on unmanned, low Earth orbit and inner planetary missions is noted. The development of PV technology along the two paths of high efficiency and high power is discussed. The importance of increasing the service life of PV systems is covered. R.J.F.

N87-26424*# Spectrolab, Inc., Sylmar, Calif.

DESIGN STUDY OF LARGE AREA 8 CM X 8 CM WRAPTHROUGH CELLS FOR SPACE STATION

GEORGE F. J. GARLICK and DAVID R. LILLINGTON *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology 1986. High Efficiency, Space Environment and Array Technology p 87-97 Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 10B

The design of large area silicon solar cells for the projected NASA space station is discussed. It is based on the NASA specification for the cells which calls for an 8 cm by 8 cm cell of wrapthrough type with gridded back contacts. The beginning of life (BOL) power must be 1.039 watts per cell or larger and maximum end of life (EOL) after 10 years in the prescribed orbit under an equivalent 1MeV electron radiation damage fluence of 5 times 10 to the 13th power e/square cm. On orbit efficiency is to be optimized by a low thermal absorptance goal (thermal alpha) of .63. Author

N87-26429*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ADVANCED PHOTOVOLTAIC SOLAR ARRAY DESIGN ASSESSMENT

PAUL STELLA and JOHN SCOTT-MONCK *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology 1986. High Efficiency, Space Environment and Array Technology p 145-150 Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 10B

The Advanced Photovoltaic Solar Array (APSA) program seeks to bring to flight readiness a solar array that effectively doubles the specific power of the Solar Array Flight Experiment/Solar Electric Propulsion (SAFE/SEP) design that was successfully demonstrated during the Shuttle 41-D mission. APSA is a critical intermediate milestone in the effort to demonstrate solar array technologies capable of 300 W/kg and 300 W/square m at beginning of life (BOL). It is not unreasonable to anticipate the development of solar array designs capable of 300 W/kg at BOL for operational power levels approx. greater than 25 kW sub e. It is also quite reasonable to expect that high performance solar arrays capable of providing at least 200 W/kg at end of life for most orbits now being considered by mission planners will be realized in the next decade. Author

N87-26447*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE STATION POWER SYSTEM

COSMO R. BARAONA *In its* Space Photovoltaic Research and Technology 1986. High Efficiency, Space Environment and Array Technology p 321-332 Jun. 1987 Previously announced as N86-32521
Avail: NTIS HC A16/MF A01 CSCL 10B

The major requirements and guidelines that affect the space station configuration and power system are explained. The evolution of the space station power system from the NASA program development-feasibility phase through the current preliminary design phase is described. Several early station concepts are described and linked to the present concept. Trade study selections of photovoltaic system technologies are described in detail. A summary of present solar dynamic and power management and distribution systems is also given. Author

N87-26452*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH POWER/LARGE AREA PV SYSTEMS

JOSEPH WISE (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.) and COSMO BARAONA *In its* Space Photovoltaic Research and Technology 1986. High Efficiency, Space Environment and Array Technology p 355-359 Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 10B

The major photovoltaic power system technology drivers for a wide variety of mission types were ranked. Each technology driver was ranked on a scale of high, medium, or low in terms of importance to each particular mission type. The rankings were then compiled to determine the overall importance of each driver over the entire range of space missions. In each case cost was ranked the highest. Author

N87-26699*# Prairie View Agricultural and Mechanical Coll., Tex. Dept. of Electrical Engineering.

SPACE STATION ELECTRICAL POWER DISTRIBUTION ANALYSIS USING A LOAD FLOW APPROACH

ERVIN M. EMANUEL *In* NASA. Lyndon B. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1986, Volume 1 12 p Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 05A

The space station's electrical power system will evolve and grow in a manner much similar to the present terrestrial electrical power system utilities. The initial baseline reference configuration will contain more than 50 nodes or busses, inverters, transformers, overcurrent protection devices, distribution lines, solar arrays, and/or solar dynamic power generating sources. The system is designed to manage and distribute 75 KW of power single phase or three phase at 20 KHz, and grow to a level of 300 KW steady state, and must be capable of operating at a peak of 450 KW for 5 to 10 min. In order to plan far into the future and keep pace with load growth, a load flow power system analysis approach must be developed and utilized. This method is a well known energy assessment and management tool that is widely used throughout the Electrical Power Utility Industry. The results of a comprehensive evaluation and assessment of an Electrical Distribution System Analysis Program (EDSA) is discussed. Its potential use as an analysis and design tool for the 20 KHz space station electrical power system is addressed. Author

N87-28186# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

COMPUTER MODELING OF HIGH-VOLTAGE SOLAR ARRAY EXPERIMENT USING THE NASCAP/LEO (NASA CHARGING ANALYZER PROGRAM/LOW EARTH ORBIT) COMPUTER CODE M.S. Thesis

KARL O. REICHL, JR. Jun. 1987 211 p
(AD-A182589; AFIT/GE/ENG/87J-2) Avail: NTIS HC A10/MF A01 CSCL 10B

The relationship between the Interactions Measurement Payload for Shuttle (IMPS) flight experiment and the low Earth orbit plasma environment is discussed. Two interactions (parasitic current loss and electrostatic discharge on the array) may be detrimental to mission effectiveness. They result from the spacecraft's electrical potentials floating relative to plasma ground to achieve a charge flow equilibrium into the spacecraft. The floating potentials were driven by external biases applied to a solar array module of the Photovoltaic Array Space Power (PASP) experiment aboard the IMPS test pallet. The modeling was performed using the NASA Charging Analyzer Program/Low Earth Orbit (NASCAP/LEO) computer code which calculates the potentials and current collection of high-voltage objects in low Earth orbit. Models are developed by specifying the spacecraft, environment, and orbital parameters. Eight IMPS models were developed by varying the array's bias voltage and altering its orientation relative to its motion. The code modeled a typical low Earth equatorial orbit. NASCAP/LEO calculated a wide variety of possible floating potential and current collection scenarios. These varied directly with both the array bias voltage and with the vehicle's orbital orientation. GRA

N87-28188*# International Fuel Cells Corp., South Windsor, Conn.

DEVELOPMENT OF AN ALKALINE FUEL CELL SUBSYSTEM Final Program Summary Report, 10 Apr. 1986 - 31 Mar. 1987

31 Mar. 1987 94 p
(Contract NAS9-17613)
(NASA-CR-172002; NAS 1.26:172002) Avail: NTIS HC A05/MF A01 CSCL 10A

A two task program was initiated to develop advanced fuel cell components which could be assembled into an alkaline power section for the Space Station Prototype (SSP) fuel cell subsystem. The first task was to establish a preliminary SSP power section design to be representative of the 200 cell Space Station power section. The second task was to conduct tooling and fabrication trials and fabrication of selected cell stack components. A lightweight, reliable cell stack design suitable for the SSP regenerative fuel cell power plant was completed. The design meets NASA's preliminary requirements for future multikilowatt Space Station missions. Cell stack component fabrication and tooling trials demonstrated cell components of the SSP stack design of the 1.0 sq ft area can be manufactured using techniques and methods previously evaluated and developed. Author

N87-28825*# Microsemi Corp., Torrance, Calif. Power Technology Components.

SPACE STATION POWER SEMICONDUCTOR PACKAGE

VILNIS BALODIS, ALBERT BERMAN, DARRELL DEVANCE, GERRY LUDLOW, and LEE WAGNER Sep. 1987 115 p
(Contract NAS3-24662)
(NASA-CR-180829; NAS 1.26:180829) Avail: NTIS HC A06/MF A01 CSCL 09A

A package of high-power switching semiconductors for the space station have been designed and fabricated. The package includes a high-voltage (600 volts) high current (50 amps) NPN Fast Switching Power Transistor and a high-voltage (1200 volts), high-current (50 amps) Fast Recovery Diode. The package features an isolated collector for the transistors and an isolated anode for the diode. Berylia is used as the isolation material resulting in a thermal resistance for both devices of .2 degrees per watt. Additional features include a hermetical seal for long life -- greater than 10 years in a space environment. Also, the package design resulted in a low electrical energy loss with the reduction of eddy currents, stray inductances, circuit inductance, and capacitance. The required package design and device parameters have been achieved. Test results for the transistor and diode utilizing the space station package is given. Author

N87-29959# European Space Agency, Paris (France).

PROCEEDINGS OF THE FIFTH EUROPEAN SYMPOSIUM ON PHOTOVOLTAIC GENERATORS IN SPACE

W. R. BURKE, comp. Nov. 1986 486 p Symposium held in The Hague/Scheveningen, The Netherlands 30 Sep. - 2 Oct. 1986; sponsored by ESA, the Netherlands Agengy for Aerospace Programs, and the Royal Netherlands Aircraft Factories
(ESA-SP-267; ISSN-0379-6566; ETN-87-90157) Avail: NTIS HC A21/MF A01

Some areas of discussion at the symposium are solar cell technology, module technology, solar arrays, environmental interaction, in-flight performance,and alternative power generation. Also, cell assembly technology, solar array analytical modeling, and tests and measurements were discussed. ESA

N87-29960# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE SPACE STATION POWER SYSTEM

COSMO R. BARAONA *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 3-11 Nov. 1986
Avail: NTIS HC A21/MF A01

The major requirements and guidelines that affect the NASA Space Station configuration and the power system are explained. The evolution of the Space Station power system from the NASA program development-feasibility phase through the preliminary design phase is described. Early station concepts, both fanciful and feasible, are described and linked to the present concept. The Phase B trade study selections of photovoltaic system technologies are detailed. Solar dynamic and power management and distribution systems are summarized. ESA

N87-29961# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ALTERNATIVE POWER GENERATION CONCEPTS FOR SPACE

HENRY W. BRANDHORST, JR., ALBERT J. JUHASZ, and BARBARA I. JONES *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 13-19 Nov. 1986
Avail: NTIS HC A21/MF A01

Trade and optimization studies that highlight the potential of solar and nuclear dynamic systems relative to photovoltaic power systems are summarized. The solar dynamic case is the LEO Stirling system, while the nuclear system is the SP-100 system goal. Nuclear systems have the potential for the lightest weight, least area, sunlight independent, radiation-durable system. Solar dynamic systems pose a stiff challenge to photovoltaic systems in the midaltitudes because of their insensitivity to the Van Allen radiation belts. While the initial operational capability space station power system is only slightly superior to the SOA PV system, with development focused on the key technologies, advanced solar dynamic systems are fully competitive in LEO midaltitudes with the advanced photovoltaic systems. Advances in energy storage systems (100 Whrs/kg required) are essential. ESA

N87-29972# Centre National d'Etudes Spatiales, Toulouse (France).

THE HIGH PERFORMANCE SOLAR ARRAY GSR3

A. MAMODE, J. BARTEVIAN, J. L. BASTARD, P. AUFFRAY, and A. PLAGNE (Societe Nationale Industrielle Aerospatiale, Les Mureaux, France) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 95-103 Nov. 1986
Avail: NTIS HC A21/MF A01

A fold out solar array with carbon-frame panel structure and stirrup-fastening peripheral hold-down concept for communication satellites in multiple payload launches was developed. Over 35W/kg end of life is achieved by using BSR 180 micron classic solar cells. Computation shows that the 50W/kg line can be surpassed with 50 micron BSFR solar cells. Modularity and versatility as well as expected performances suggest an extension to domains such as low-orbit missions, space stations, and retractable solar arrays. ESA

N87-29973# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
EURECA APPLICATION OF THE RETRACTABLE ADVANCED RIGID ARRAY (RARA) SOLAR ARRAY
J. DEKAM *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 105-114 Nov. 1986
Avail: NTIS HC A21/MF A01

A reusable, retractable solar array for low Earth orbit free flyers was designed. The design can be applied for power up to 10 kW, but can be extended. The rigid concept allows for a simple and therefore reliable and cost effective design. A high design flexibility with respect to wing lay out and interface is featured. It will be applied on EURECA in a 5 kW version. ESA

N87-29975# Royal Netherlands Aircraft Factories Fokker, Amsterdam.
THE INMARSAT SOLAR ARRAY: THE FIRST ADVANCED RIGID ARRAY (ARA) TO FLY
PH. J. ZIJDEMANS *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 123-127 Nov. 1986
Avail: NTIS HC A21/MF A01

Design and verification of a project solar array from a generic concept are described. Part level and wing level testing prove that the rigid design option yields a viable and promising solar array family, capable of delivering 30 to 40 W/kg, 10 yr end of life, within the range of application of 1 to 4 kW. ESA

N87-29976# AEG-Telefunken, Wedel (West Germany).
HIGH POWER SOLAR ARRAY TECHNOLOGIES
G. BEHRENS *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 131-136 Nov. 1986
Avail: NTIS HC A21/MF A01

Potential high power solar arrays for the Columbus program were investigated with regard to critical technologies needed for their electrical parts. The investigations and assessments for definition of technology items where specific problems exist and further work is necessary are described. Main problem areas are the harness concept, manufacturing, and high voltage and environmental aspects. ESA

N87-29977# Marconi Space Systems Ltd., Portsmouth (England).
GAAS CONCENTRATOR SOLAR ARRAYS
J. M. HARVEY, J. HOWARD, and D. HAYWOOD *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 137-144 Nov. 1986
Avail: NTIS HC A21/MF A01

The planar trough concentrators (PTC) for the Olympus and Cassegrain concentrators for the Columbus solar arrays were compared. The study of the PTC shows that it is a feasible concept, retaining the major configuration of a planar array. The PTC gives a 10 percent mass saving, and 40 percent area reduction, over a GaAs planar as well as a 40 percent reduction in quantity of cells required. These savings of mass, area, and cell costs make the GaAs PTC a worthwhile contender for geostationary satellites. Although the Cassegrain concentrator appears disadvantageous against planar GaAs in terms of mass and area, the saving in cells of 75 percent and in bulk cell material of 98.5 percent gives the Cassegrain a large cost advantage. The large number of 2 x 2 cm GaAs cells required is considered beyond present supply capability for the planar solution. Therefore the Cassegrain concentrator is advantageous for large LEO spacecraft. ESA

N87-29979# Royal Netherlands Aircraft Factories Fokker, Amsterdam.
THE FOKKER STRONGBACK SOLAR ARRAY
R. ZWANENBURG *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 151-157 Nov. 1986
Avail: NTIS HC A21/MF A01

The Strongback solar array with rigid solar panels offers a design solution for power levels up to 40 kW. The strongback array deploys the panels simultaneously in a synchronized way. The deployment is actuated by deployment springs. Deployment control and retraction is possible. High strength and stiffness in deployed condition is obtained by the preloaded truss-type structure. A life size model of 9 m length demonstrates the performances. ESA

N87-29980# Centre d'Etudes et de Recherches, Toulouse (France). Dept. Technologie Spatiale.
MARECS AND ECS ANOMALIES: ATTEMPT AT INSULATION DEFECT PRODUCTION IN KAPTON
L. LEVY, R. REULET, D. SARRAIL, J. M. SIGUIER, and H. LECHTE (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 161-169 Nov. 1986
Avail: NTIS HC A21/MF A01

Experiments were conducted on solar array samples to reproduce the short circuits assumed to be responsible for the ECS and MARECS in-orbit power losses. Discharges were produced between the interconnects and the cover-slides according to the inverted gradient voltage concept in presence of the solar array voltage. The theory that such low voltages could maintain an arc, leading to a permanent short circuit, burning away the Kapton, provided the discharge be triggered by a higher voltage was assessed. It was not possible to produce any permanent insulation defect through the insulation Kapton layer. The discharges by themselves are clearly not sufficient to produce the failure. ESA

N87-29981# Fraunhofer-Inst. fuer Kurzzeitdynamik, Weil am Rhein (West Germany).
MICROMETEORITE IMPACT ON SOLAR PANELS
E. SCHNEIDER *In* ESA Proceedings on the Fifth European Symposium on Photovoltaic Generators in Space p 171-174 Nov. 1986
Avail: NTIS HC A21/MF A01

A micrometeorite simulation program studied damage phenomena and failure mechanisms of solar panels under hypervelocity impact conditions, to see if space debris and micrometeorites cause short circuits in solar arrays, e.g., of MARECS-A satellite. Experiments demonstrate that transient and permanent short circuits can be produced by particle impact. Arc discharges can be initiated under realistic electrical power conditions. There is evidence that failures caused by impact induced short circuits can be minimized by improving the geometrical arrangement of the panels and by optimizing the electrical circuitry. ESA

N87-29982# Technische Univ., Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik.
MICROMETEORITE EXPOSURE OF SOLAR ARRAYS
U. WEISHAUPT, H. KUCZERA, and M. ROTT *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 175-180 Nov. 1986
(Contract ESA-6238/85-NL-AN)
Avail: NTIS HC A21/MF A01

Permanent losses of a part of the available power on solar arrays of ESA satellites, possibly caused by micrometeoroid or space debris impacts were studied in hypervelocity impact simulations at a plasma accelerator using ECS and Olympus solar panel structures. Results confirm that significant damage of the solar arrays can be caused by small hypervelocity particles. Using a solar array simulator connected to the test sample, penetration phenomena and arc triggering effects were investigated within the efficiency range of the accelerator. Temporary or permanent short circuits between the solar cells and the panel structure may lead to a loss of solar array power and additional damage may be created if arcing occurs. ESA

N87-28994# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

STOPPING DIFFERENTIAL CHARGING OF SOLAR ARRAYS

H. G. LECHTE *In its* Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 189-193 Nov. 1986

Avail: NTIS HC A21/MF A01

Assuming that the build up of electrostatic charge on solar arrays of geostationary satellites is a contributing factor in reducing the lifetime of insulators, the mechanism of charging the elements of a rigid solar array was analyzed and means to reduce differential charging proposed. These include avoidance of charging the array rear, a better matching of secondary emission yields between both faces of the array, and the provision of an electrical leakage path between cover slips and solar cells to bleed off any charge. It is advised that the design of solar generators for geostationary missions takes seriously into account the build up of electrostatics and provides for sufficient precautions against resulting stresses, including those from micrometeorites. ESA

N87-28995# Centro Informazioni Studi Esperienze, Milan (Italy).

ADVANCED SOLAR GAAS ARRAY (ASGA) EXPERIMENT ON EURECA: FLIGHT OBJECTIVES AND INSTRUMENT CONFIGURATION

L. BERTOTTI, C. FLORES, F. PALETTA, and L. ZULIANI (Consiglio Nazionale delle Ricerche, Rome, Italy) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 197-202 Nov. 1986 Sponsored by CNR

Avail: NTIS HC A21/MF A01

The Advanced Solar GaAs Array (ASGA) experiment consists of a solar panel with different GaAs solar cells to be flown by EURECA-1. During the whole mission electrical and thermal data relevant to different strings of cells are automatically recorded by dedicated electronics to check the performance trend of GaAs solar cells when exposed to the low Earth orbit environment. The EURECA flight gives an opportunity to evaluate the properties of standard and advanced GaAs solar cells over a period of 6 months. The EURECA environment (the same as that for the future space station) is characterized by: high number of eclipses, low radiation density, and atomic oxygen erosion. The ASGA experiment tests the effects of these physical aspects on different kind of cells. On the solar panel, concentrator and planar cells will be mounted. ESA

N87-28996# Societe Nationale Industrielle Aerospatiale, Cannes (France).

SPOT SOLAR ARRAY IN-ORBIT DEPLOYMENT RESULTS EVALUATION

PH. BOBO *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 203-206 Nov. 1986

Avail: NTIS HC A21/MF A01

The design and deployment sequence of the SPOT satellite flexible solar array are recalled. The analysis tools whereby in-orbit behavior can be retrieved are described. Results from telemetry deliveries are presented and evaluated to derive solar generator flight data. Performances are compared to predictions or simulations. The performance budget shows good performance-prediction correlation, increasing confidence level for this solar array subsystem, three specimens of which are in production. ESA

N87-29004# Telespazio, S.p.A., Rome (Italy).

THERMAL-ELECTRICAL DYNAMICAL SIMULATION OF SPACECRAFT SOLAR ARRAY

M. RETICCIOLI *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 317-326 Nov. 1986

Avail: NTIS HC A21/MF A01

An approach to model, in an electrical analogy, a spacecraft solar array in the space environment during operating life is outlined. Thermal and electrical coupling effects are dynamically taken into account, so that the thermal and electrical behavior during spacecraft transient events can be simulated. The model takes into account other factors affecting the output power, such as illumination, environmental conditions, and seasonal and aging factors. Since the model is defined in terms of equivalent electrical circuits a general purpose circuit simulation program, such as SPICE, can be utilized. Results of simulations are reported. ESA

N87-29008# Indian Space Research Organization, Bangalore.

DESIGN AND FABRICATION OF STRETCHED ROHINI SATELLITE-1 SOLAR ARRAY

N. SRINIVASAMURTHY, M. SUDHAKAR, B. L. AGRAWAL, and A. U. GOPALAN (Indian Space Research Organization, Trivandrum.) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 333-342 Nov. 1986

Avail: NTIS HC A21/MF A01

The SROSS satellites solar array studies and selected configuration are described. Mission demands are such that spinning and three axis stabilized satellites are required. A single bus satellite design catering to both types of mission requirements was envolved, imposing severe constraints on the solar array design. The satellite structure is an octagonal cylinder. The eight deployed panels are stowed against the corresponding body mounted fixed panels. The deployed panels contain cell on both sides and each deployed panel makes an angle of 135 deg with the corresponding body mounted panel when deployed. A modification in this configuration is to distribute the deployable panels on each end of the octagon. The SROSS satellites require 96 W raw power for 3 axis stabilized versions, 66 W for spinners. ESA

N87-29010# Lockheed Missiles and Space Co., Sunnyvale, Calif.

TEST RESULTS FROM THE SOLAR ARRAY FLIGHT EXPERIMENT

GARY F. TURNER and MIKE D. MENNING *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 365-372 Nov. 1986

Avail: NTIS HC A21/MF A01

The Solar Array Flight Experiment flown on STS-41D demonstrated the readiness of this technology and associated analytical tools to support advanced programs such as Space Station. The solar array, which measured 4.5 x 31.5 m, was successfully deployed and retracted several times during the mission, and electrical, mechanical, and dynamic performance was observed and measured, with excellent correlation with preflight predictions. ESA

N87-29882*# AEC-Able Engineering Co., Inc., Goleta, Calif.

SPACE STATION ALPHA JOINT BEARING

MICHAEL R. EVERMAN, P. ALAN JONES, and PORTER A. SPENCER (Lockheed Missiles and Space Co., Sunnyvale, Calif.) *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 329-343 May 1987

Avail: NTIS HC A16/MF A01 CSCL 13I

Perhaps the most critical structural system aboard the Space Station is the Solar Alpha Rotary Joint which helps align the power generation system with the sun. The joint must provide structural support and controlled rotation to the outboard transverse booms as well as power and data transfer across the joint. The Solar Alpha Rotary Joint is composed of two transition sections and an integral, large diameter bearing. Alpha joint bearing design presents a particularly interesting problem because of its large size and need for high reliability, stiffness, and on orbit maintability. The discrete roller bearing developed is a novel refinement to cam follower technology. It offers thermal compensation and ease of on-orbit maintenance that are not found in conventional rolling element bearings. How the bearing design evolved is summarized. Driving requirements are reviewed, alternative concepts assessed, and the selected design is described. Author

N87-29915*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATUS OF SPACE STATION POWER SYSTEM
COSMO R. BARAONA and DEAN W. SHEIBLEY *In its* Space Electrochemical Research and Technology (SERT) p 1-8 Sep. 1987
Avail: NTIS HC A16/MF A01 CSCL 22B

The major requirements and guidelines that affect the manned space station configuration and the power systems are explained. The evolution of the space station power system from the NASA program development feasibility phase through the current preliminary design phase is described. Several early station concepts are described and linked to the present concept. The recently completed phase B tradeoff study selections of photovoltaic system technologies are described. The present solar dynamic and power management and distribution systems are also summarized for completeness. Author

N87-29917*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL FUTURE MISSIONS AND ENERGY STORAGE TECHNOLOGY IMPLICATIONS Abstract Only
EUGENE V. PAWLIK *In* NASA-Lewis Research Center, Space Electrochemical Research and Technology (SERT) p 15 Sep. 1987
Avail: NTIS HC A16/MF A01 CSCL 10C

The mission model for JPL future programs is presented. This model identifies mission areas where JPL is expected to have a major role and/or participate in a significant manner. These missions are focused on space science and applications missions, but they also include some participation in space station activities. The mission model is described in detail followed by a discussion on the needs for energy storage technology required to support these future activities. Author

N87-29938*# Texas A&M Univ., College Station. Dept. of Chemical Engineering.
REGENERATIVE FUEL CELLS FOR SPACE APPLICATIONS
A. JOHN APPLEBY *In* NASA-Lewis Research Center, Space Electrochemical Research and Technology (SERT) p 213-220 Sep. 1987
Avail: NTIS HC A16/MF A01 CSCL 10C

After several years of development of the regenerative fuel cell (RFC) as the electrochemical storage system to be carried by the future space station, the official stance has now been adopted that nickel hydrogen batteries would be a better system choice. RFCs are compared with nickel hydrogen and other battery systems for space platform applications. Author

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ELECTRONICS

Includes descriptions of analytical techniques, analyses, systems, and requirements for internal and external communications, electronics, sensors for position and systems monitoring and antennas.

A87-31461*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION INTEGRATION AND VERIFICATION CONCEPTS
EDWARD S. CHEVERS (NASA, Johnson Space Center, Houston, TX) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 93-99.

The TAVERNS concept for the integration, verification, and maintenance of the Space Station avionics and payload systems is described. The functional requirements which TAVERNS integrates are discussed, showing the mode of integration and the flight systems integration. The top and bottom TAVERNS sections are described, and the use of TAVERNS to develop software required for flight applications and testing is discussed. C.D.

A87-31462* RCA Communications Systems Div., Camden, N. J.
MULTIPLE ACCESS KU-BAND COMMUNICATIONS SUBSYSTEM FOR THE SPACE STATION
G. E. MACKIW (RCA, Communication and Information Systems Div., Camden, NJ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 100-104.
(Contract NAS9-17471)

This paper presents the results of advanced work on system design for the Space Station Multiple Access Subsystem (SSMAS), which includes equipment aboard the Space Station itself and aboard the space-borne group of user vehicles. In addition to the system development efforts, early hardware design work is being performed. A Ku-band transceiver representing the EVA or other equipment configuration has been breadboarded and system testing performed. Additional hardware is being designed for NASA JSC, which will be assembled to form a SSMAS test bed where the subsystem itself, as well as its hardware components, will be tested and evaluated. Author

A87-32235*# Old Dominion Univ., Norfolk, Va.
ROBUST CONTROLLER SYNTHESIS FOR A LARGE FLEXIBLE SPACE ANTENNA
N. SUNDARARAJAN (Old Dominion University Research Foundation, Norfolk, VA), S. M. JOSHI, and E. S. ARMSTRONG (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 201-208. refs

The linear-quadratic Gaussian/loop-transfer-recovery method is used to synthesize a fine-pointing control system for a large space antenna. A finite-element model for the 122-m hoop/column antenna is employed, and a compensator, utilizing attitudes sensors and torque actuators, is designed which achieves pointing performance while maintaining stability robustness to unmodeled dynamics. Inclusion of the rigid-body modes plus the first three elastic modes is found to be necessary to achieve a 0.1-rad/s bandwidth. Results are obtained by employing a modification of the standard robustness recovery procedure, which reduces the conservative nature of the design methodology. Performance degradation is encountered due to the presence of unavoidable invariant zeros within the design bandwidth. Author

A87-34797
COMMUNICATION MISSIONS FOR GEOSTATIONARY PLATFORMS
TAKASHI IIDA, MASAAKI SHIMADA, SHIGETOSHI YOSHIMOTO, YOSHIAKI SUZUKI, and KAZUHIKO HASHIMOTO (Ministry of Posts and Telecommunications, Radio Research Laboratory, Koganei, Japan) Space Communication and Broadcasting (ISSN 0167-9368), vol. 4, Dec. 1986, p. 425-433. refs

It is estimated that several thousand transponders will be needed in the 36 MHz slot by the year 2000 by the U.S. and Japan, while the GEO position above the U.S. will be congested and the slot above Japan is shared by the Soviets. Additional demands may arise from the development of mobile communications services in Japan and the U.S. A large GEO platform could benefit from the economies of scale by making servicing an economical prospect. The platform could carry 50/40 GHz antennas for personal radio communications, multibeam DBS antennas, a mobile telephone system functioning at 900/800 MHz, a relay station for earth-moon communications, and global data relay system. The limitations and necessary operational parameters of each system are examined. M.S.K.

A87-40380
ON-BOARD COMMUNICATIONS, INCLUDING EVA
THOMAS L. LINDLEY (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 256-259.

The Space Station will serve as a central node in a major communications network. It will service a large variety of users located at numerous ground sites and in a number of coorbiting and polar orbiting free flying satellites, platforms, and associated support spacecraft, such as the Shuttle Orbiter, Orbiter Maneuvering Vehicles, and future Orbiter Transfer Vehicles. Space to ground communications will be through the Tracking and Data Relay Satellite System or through equivalent systems. In addition to the external communications nodes, there will be a large number of complex on-board payloads and video cameras that will generate data that must pass through the Tracking and Data Relay Satellite System to associated ground based Payload/Operation Centers. A Space to Space Communications System provides a link between Space Station and EVA astronauts. Author

A87-41302#
CARBON FIBRE SLOTTED WAVEGUIDE ARRAYS
R. WAGNER (Dornier System GmbH, Friedrichshafen, West Germany) IN: Military microwaves '86; Proceedings of the Conference, Brighton, England, June 24-26, 1986 . Tunbridge Wells, England, Microwave Exhibitions and Publishers, Ltd., 1986, p. 231-236. Research sponsored by the Swedish Space Corp., DFVLR, BMFT, and ESA.

Spaceborne SARs call for antennas of large aperture and high structural performance; attention is accordingly given to the slotted waveguide antenna concept, which yields high aperture efficiency, good beam-shaping, and low losses in conjunction with great compactness and high stiffness. A distinctive technology for the manufacture of such waveguides from metallized carbon fiber-reinforced plastics, as well as for the construction of radiating arrays for such waveguides, is presented. O.C.

A87-41609*# Systems Science and Software, La Jolla, Calif.
THEORY OF PLASMA CONTACTORS FOR ELECTRODYNAMIC TETHERED SATELLITE SYSTEMS
D. E. PARKS and I. KATZ (Systems, Science and Software, La Jolla, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, May-June 1987, p. 245-249. Previously announced in STAR as N86-28430. refs
(Contract NAS3-23881)

Recent data from ground and space experiments indicate that plasma releases from an object dramatically reduce the sheath impedance between the object and the ambient plasma surrounding it. Available data is in qualitative accord with the theory developed to quantify the flow of current in the sheath. Electron transport in the theory is based on a fluid model of a collisionless plasma with an effective collision frequency comparable to frequencies of plasma oscillations. The theory leads to low effective impedances varying inversely with the square root of the injected plasma density. To support such a low impedance mode of operation using an argon plasma source, for example, requires that only one argon ion be injected for each thirty electrons extracted from the ambient plasma. The required plasma flow rates are quite low; to extract one ampere of electron current requires a mass flow rate of about one gram of argon per day. Author

A87-45483* LinCom Corp., Los Angeles, Calif.
FDMA SYSTEM DESIGN AND ANALYSIS FOR SPACE STATION
CHIT-SANG TSANG, CHAK-MING CHIE (LinCom Corp., Los Angeles, CA), and JAMES E. RATLIFF (NASA, Johnson Space Center, Houston, TX) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 133-137. refs
(Contract NAS9-17332)

Space Station FDMA communications system requirements, design, and analysis are addressed. The analysis is primarily based on numerical results generated by a computer simulation system called SCSS. The time-line communications performance during real time mission operation is also discussed. The purpose of this paper is three-fold: introduction to Space Station multiple access communications system requirements, demonstration of system analysis by a computer tool, and design of an FDMA communications system for the Space Station. Author

A87-45519* Harris Government Aerospace Systems Div., Melbourne, Fla.
MULTIPLE BEAM PHASED ARRAY FOR SPACE STATION CONTROL ZONE COMMUNICATIONS
P. B. HALSEMA (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 818-821.
(Contract NAS9-17472)

The Space Station Communications Control Zone is a disk shaped region 40 nautical miles in diameter and 10 nautical miles thick centered about the Space Station. It is estimated that 6 simultaneous Multiple Access (MA) channels will be required to satisfy the projected communications needs within this zone. These channels will be used to communicate with MA users located anywhere within the Control Zone. This paper details the tradeoffs and design implementation of a multiple beam integrated phased array to provide antenna coverage of the Control Zone. The array is a compact, modular assembly using Gallium Arsenide circuits, microstrip elements, and advanced packaging techniques. This results in a small, reliable antenna system capable of meeting the projected Space Station requirements and flexible enough to grow and evolve as the Space Station communications needs develop. Author

A87-45520
SPACE STATION TRACKING SUBSYSTEM SENSOR EVALUATION
JAMES T. YONEMOTO and GREGG E. BURGESS (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 822-825.

Candidate U.S. Space Station tracking subsystem sensors were identified and evaluated on the preliminary design phase of the Space Station program. The sensors investigated included radars, laser-based sensors, Global Positioning System receivers, passive electro-optical sensors, and video tracking systems. Both individual snsors and complements of sensors were evaluated for their ability to support assumed vehicular operations in the vicinity of the Station. Two of these sensors, the passive electro-optical and video tracking sensors, are described. Analyses and dynamic performance simulations indicate that each can meet the postulated performance requirements. Author

A87-45522
END-TO-END COMMUNICATIONS FOR SPACE STATION
S. BRUCE FRANKLIN, CHARAN J. LANGTON, ROBERT E. VAUGHAN, and ROBERT M. WARD, JR. (TRW, Inc., TRW Electronic Systems Group, Redondo Beach, CA) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 832-837.

The top level problem of transporting a complex mix of data between the multitude of terminals and users that comprise the Space Station community is addressed in this paper. The end-to-end communications architecture is partitioned into relatively independent segments related to space-to-ground communications via the Tracking and Data Relay Satellite System (TDRSS), space-to-space communications via a new multiple-access communications system, and ground-to-ground communications via existing and needed capabilities. Partitions are also defined within the three major nodes - onboard the Space Station; onboard polar and coordinating platforms or free flyers; and within major NASA centers. Emphasis is on data communications within and between the major nodes; data transfer concepts, capabilities, and limitations. Author

A87-45524* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION MULTIPLE ACCESS COMMUNICATIONS SYSTEM
NANCI A. OLSON (NASA, Johnson Space Center, Houston, TX) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 843-846.

The development of a multiple access communications system (MACS) for the space-to-space communications on the Space Station is discussed. The communications capabilities of the FHMA, CDMA, TDMA, SDMA, and FDMA techniques are evaluated; FDMA was selected for the space-to-space communications on the Space Station because of its lower complexity and growth capability. The proposed space-to-space multiple access system for the Space Station is a digitally modulated Ku-band FDMA system with a distributed architecture; this system would transmit on frequencies between 13.4 and 13.7 GHz and receive on frequencies between 14.6 and 14.89 GHz, and the bandwidth will support seven high-data-rate users and 12 low-data-rate users. The IF components and antennas for the MACS are examined. A multiple access breadboard design is described. I.F.

A87-46281
ON-BOARD K- AND S-BAND MULTI-BEAM ANTENNAS
TAKAO ITANAMI, MASAHIRO MINOMO, and KENJI UENO (Nippon Telegraph and Telephone Public Corp., Radio Communications Networks Laboratories, Musashino, Electrical Communications Laboratories, Review (ISSN 0029-067X), vol. 35, March 1987, p. 159-167. refs

This paper describes the configurations and performances of foldable 1.3 m K- and 3.5 m S-band offset Cassegrain multibeam antenna module on a three axes stabilized bus. This module is accommodated to a limited launch vehicle payload area of 2.2 m in inner diameter and 2.8 m in height. Electrical and structural tests results confirm that manufactured antenna characteristics agree well with the design values and that these antennas are well suited to on-board equipment. Author

A87-50157#
DESIGN OF A BEACON RECEIVING SYSTEM FOR THE OLYMPUS SATELLITE
ERKKI SALONEN (Helsinki University of Technology, Espoo, Finland) IN: International Beacon Satellite Symposium on Radio Beacon Contribution to the Study of Ionization and Dynamics of the Ionosphere and to Corrections to Geodesy and Technical Workshop, Oulu, Finland, June 9-14, 1986, Proceedings. Part 2 . Oulu, Finland, University of Oulu, 1986, p. 359-365. refs

The main features of the design of the propagation measurement system for the 12.5, 20, and 30 GHz Olympus 1 satellite beacons are described. Progress being made at the Metsaehovi Radio Research Station in Finland is discussed. The main goals of the propagation measurement are to collect statistics of attenuation, scintillation, and crosspolarization events. The propagation payload of Olympus 1 is discussed as well as the choice of the frequency for the main phase-locked loop, the antenna and feed system, and data acquisition. K.K.

A87-50417#
ROBUST CONTROL OF A LARGE SPACE ANTENNA
MICHAEL F. BARRET and DANIEL J. BUGAJSKI (Honeywell Systems and Research Center, Minneapolis, MN) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 124-132. refs
(AIAA PAPER 87-2253)

A methodology is developed for designing feedback control laws to accomplish large-angle (45 deg) slew maneuvers for a large space antenna and rapidly settle to within microrad pointing accuracy. It is shown that control torque requirements for settling critical antenna responses exceed current state-of-the-art (SOA) hardware capability by 2-3 orders of magnitude. An improved reaction control system was developed which substantially reduces the excitation of critical flexible modes. It is concluded that the performance criteria can be met using SOA control hardware, while robustness to unstructured uncertainty can be realized at either the input or output of the feedback loop. K.K.

N87-20339*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF SPACE PLASMA DISCHARGE ON THE PERFORMANCE OF LARGE ANTENNA STRUCTURES IN LOW EARTH ORBIT
HANS-JUERGEN C. BLUME Feb. 1987 21 p
(NASA-TM-89118; NAS 1.15:89118) Avail: NTIS HC A02/MF A01 CSCL 20I

The anomalous plasma around spacecrafts in low Earth orbit represents the coma of an artificial comet. The plasma discharge is caused by an energetic disturbance of charged particles which were formerly in a state of equilibrium. The plasma can effect the passive and active radio frequency operation of large space antennas by inducing corona discharge or strong arcing in the antenna feeds. One such large space antenna is the 15-meter hoop column antenna which consists of a mesh membrane material (tricot knitted gold plated wire) reflector and carbon fiber tension cords. The atomic oxygen in the plasma discharge state can force the wire base metal particles through the gold lattice and oxydize the metal particles to build a Schottky-barrier contact at the point where the wires meet. This effect can cause strong deviations in the reflector performance in terms of antenna pattern and losses. Also, the carbon-fiber cords can experience a strength reduction of 30 percent over a 40-hour exposure time. Author

N87-20380# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DYNAMIC ANALYSIS OF DIRECT TELEVISION SATELLITE TV-SAT/TDF.1
Y. PLUMAT *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 8 p Jul. 1986
Avail: NTIS HC A12/MF A01

An application of the methods of analysis for the structural behavior of spacecraft whose bottom is affected by a vibrational environment is discussed. The application concerns the Direct Broadcast satellites TV-SAT and TDF.1, for which sine vibration qualification and acceptance are achieved through combination of the theoritical analysis (finite element method and frequential response) and of the experimental (sine vibrations test) verification of some subsystems and system assemblies. This procedure requires highly detailed mathematical models, which are validated by way of in depth correlation between the test predictions and test dynamic results. TV-SAT and TDF.1 satellites are a specially worthwhile illustration for the said type of studies as they are a pair of large, wholly European built spacecrafts whose structures are made up of several major subassemblies, namely: main body, propellant tanks, Antenna module complete with reflectors, solar array. Author

N87-22876# Naval Postgraduate School, Monterey, Calif.
THE EFFECT OF MULTIPATH ON DIGITAL COMMUNICATIONS SYSTEMS: WITH APPLICATION TO SPACE STATION M.S. Thesis
WILLIAM J. TOTI Dec. 1986 96 p
(AD-A178578) Avail: NTIS HC A05/MF A01 CSCL 17B

Analysis of the effect of multipath propagation on digital communications systems was conducted. A brief overview of the root causes of multipath propagation was included in this discussion. Probabilities of error were then derived for a generalized digital communications system experiencing Rician fading due to multipath propagation. Exact results were obtained for equiprobable M-ary Frequency Shift Keyed and M-ary Phase Shift Keyed modulation schemes used to transmit digital data. Furthermore, the probability of error was obtained for a generalized digital communication system experiencing single-bit intersymbol interference due to multipath propagation. Finally, the performance of digital communication links for NASA's space station operating in the presence of intersymbol interference was evaluated. Results obtained tend to show that severe communication system performance degradation may occur on those links under certain transmitter/receiver and space station geometries. GRA

N87-24499*# Honeywell Systems and Research Center, Minneapolis, Minn.

ROBUST CONTROL FOR LARGE SPACE ANTENNAS

M. F. BARRETT *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 637-664 Jun. 1987

Avail: NTIS HC A14/MF A01 CSCL 13I

A brief description of program objectives and the space based radar application is given. General characteristics of the 100 m diameter reflector spacecraft are described along with the intended mission and associated requirements, and dynamic characteristics relevant to that mission. Preliminary control analyses are carried out for the critical rapid slew and settle maneuver to establish feedback control requirements and fundamental limitations in meeting those requirements with control hardware for a baseline reaction control system (RCS) jet placement assumed for the open loop bang-bang slew limitations. Control moment gyros (CMGs), angular position sensors, and linear translation sensors are placed for feedback control. Control laws are designed for the improved sensor and actuator placement and evaluated for performance and robustness to unstructured model uncertainty. The robustness of the control design is assessed with respect to modal parameter uncertainty. Results of the control designs analyses are summarized, conclusions are drawn, and recommendations made for future studies. Author

N87-24503*# Martin Marietta Aerospace, Denver, Colo.

BOX TRUSS ANTENNA TECHNOLOGY STATUS

J. V. COYNER and E. E. BACHTELL *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 717-736 Jun. 1987 Previously announced as 87N-16023

Avail: NTIS HC A14/MF A01 CSCL 22B

Recent technology development activities for box truss structures and box truss antennas are summarized. Three primary activities are discussed: the development of an integrated analysis system for box truss mesh antennas; dynamic testing to characterize the effect of joint free play on the dynamic behavior of box truss structures; and fabrication of a 4.5 meter diameter offset fed mesh reflector integrated to an all graphite epoxy box truss cube. Author

N87-24504*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HOOP/COLUMN AND TETRAHEDRAL TRUSS ELECTROMAGNETIC TESTS

M. C. BAILEY *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 737-746 Jun. 1987

Avail: NTIS HC A14/MF A01 CSCL 22B

The distortion of antennas was measured with a metric camera system at discrete target locations on the surface. Given are surface distortion for hoop column reflector antennas, for tetrahedral truss reflector antennas, and distortion contours for the tetrahedral truss reflector. Radiation patterns at 2.27-GHz, 4.26-GHz, 7.73-GHz and 11.6-GHz are given for the hoop column antenna. Also given are radiation patterns at 4.26-GHz and 7.73-GHz for the tetrahedral truss antenna. E.R.

N87-24508*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ANTENNA TECHNOLOGY SHUTTLE EXPERIMENT (ATSE)

R. E. FREELAND, E. METTLER, L. J. MILLER, Y. RAHMET-SAMII, and W. J. WEBER, III *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 779-807 Jun. 1987

Avail: NTIS HC A14/MF A01 CSCL 20N

Numerous space applications of the future will require mesh deployable antennas of 15 m in diameter or greater for frequencies up to 20 GHz. These applications include mobile communications satellites, orbiting very long baseline interferometry (VLBI) astrophysics missions, and Earth remote sensing missions. A Lockheed wrap rip antennas was used as the test article. The experiments covered a broad range of structural, control, and RF discipline objectives, which is fulfilled in total, would greatly reduce the risk of employing these antenna systems in future space applications. It was concluded that a flight experiment of a relatively large mesh deployable reflector is achievable with no major technological or cost drivers. The test articles and the instrumentation are all within the state of the art and in most cases rely on proven flight hardware. Every effort was made to design the experiments for low cost. Author

N87-28959# Atomic Energy Research Establishment, Harwell (England).

SURFACE MODIFICATION TO MINIMISE THE ELECTROSTATIC CHARGING OF KAPTON IN THE SPACE ENVIRONMENT

D. VERDIN and M. J. DUCK *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 12 p May 1987 Sponsored in part by the Royal Aircraft Establishment, Farnborough, England

Avail: NTIS HC A13/MF A01

The electrostatic charging of Kapton under electron irradiation is reduced by coating it with a dispersion of indium oxide in a soluble polyimide. The proportion of oxide in the coating and its thickness are chosen to give an optimum balance between the surface resistivity and the thermo-optical properties of the film. Author

N87-28960# Air Force Geophysics Lab., Hanscom AFB, Mass.

AUTOMATIC CHARGE CONTROL SYSTEM FOR GEOSYNCHRONOUS SATELLITES

B. M. SHUMAN, H. A. COHEN, J. HYMAN, R. R. ROBSON, J. SANTORU, and W. S. WILLIAMSON (Hughes Research Labs., Malibu, Calif.) *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 17 p May 1987

Avail: NTIS HC A13/MF A01

An autonomous system to detect both absolute and differential spacecraft charging aboard high altitude satellites and to reduce those potentials before hazardous arcing levels are reached is being developed. The principle of safely reducing spacecraft charging levels by the emission of a low energy neutral plasma, effectively shorting the spacecraft and charged dielectric surfaces to the ambient space plasma, was demonstrated. The Charge Control System will utilize a xenon-based plasma source capable of igniting within one second, and capable of emmiting a quasi-neutral plasma containing more than 1 mA of ions. Author

N87-28961# Aerospace Corp., Los Angeles, Calif. Space Sciences Lab.

THICK DIELECTRIC CHARGING ON HIGH ALTITUDE SPACECRAFT

A. L. VAMPOLA *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 7 p May 1987 Previously announced as N87-13480

(Contract F04701-82-C-83)

Avail: NTIS HC A13/MF A01

Thick dielectric charging, in which energetic electrons embed within bulk dielectrics and build up to potentials in excess of the

breakdown potential of the dielectric, is shown to be a causative factor in the anomalous operation of high altitude satellites. Results of laboratory studies are reviewed and a table of maximum expected electron fluxes orbits of various altitudes is presented. The combination of maximum expected electron fluxes and the small energy associated with a bulk dielectric breakdown permits the elimination of bulk charging as a spacecraft problem through the minimum shielding (400 mg/sq cm) of all cables and circuit boards otherwise exposed to the environment, and through the desensitizing of digital logic inputs that are serviced by cables.
Author

N87-29161*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ELECTRONIC CONTROL/DISPLAY INTERFACE TECHNOLOGY
R. V. PARRISH, A. M. BUSQUETS, R. F. MURRAY, and J. J. HATFIELD *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 25 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

An effort to produce a representative workstation for the Space Station Data Management Test Bed that provides man/machine interface design options for consolidating, automating, and integrating the space station work station, and hardware/software technology demonstrations of space station applications is discussed. The workstation will emphasize the technologies of advanced graphics engines, advanced display/control medias, image management techniques, multifunction controls, and video disk utilizations.
Author

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PROPULSION/FLUID MANAGEMENT

Includes descriptions, analyses, and subsystem requirements for propellant/fluid management and propulsion systems for attitude control and orbit maintenance and transfer for the station and supporting elements such as the OMV and OTV.

A87-32945
REFUELING SATELLITES IN SPACE - THE OSCRS PROGRAM
BARNEY F. GORIN (Fairchild Space Co., Germantown, MD) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p.
(SAE PAPER 861797)

The configuration, use and overall space operations scenario envisioned for the Orbital Consumables Resupply System (OCRS) are summarized. The OCRS is to allow replenishment of consumables, product harvesting and removal of wastes from satellites from an orbital base on the Orbiter. Servicing will be carried out either directly from the Orbiter after grappling with the orbiter RMS or by a teleoperated orbital maneuvering vehicle. Systems to be serviced with the OCRS include the Space Station, Gamma Ray Observatory, free-flyers and GEO-stationed satellites. Both hypergolic and hydrazine monopropellants are to be carried in OCRS tanks in a polar mounting configuration in the Orbiter bay. Fuel transfer and pumping hardware and procedures, OCRS design features and Shuttle interface systems are outlined.
M.S.K.

A87-34712* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSFERRING SUPERFLUID HELIUM IN SPACE
PETER KITTEL (NASA, Ames Research Center, Moffett Field, CA) IN: Advances in cryogenic engineering. Volume 31. New York, Plenum Publishing Corp., 1986, p. 897-904. NASA-supported research.

A simple thermodynamic model of a transfer system for resupplying liquid helium in space is presented, with application to NASA projects including the Space Infrared Telescope Facility, the Large Deployable Reflector, and the Hubble Space Telescope. The relations between different thermodynamic regimes that can be expected in the transfer line are used to study the relative efficiencies of various possible transfer techniques. Low heat leak into the transfer line, particularly at point sources such as the coupling, is necessary for efficient transfer of liquid helium, and proper selection of supply tank temperature is important during helium resupply.
R.R.

A87-36756
DEMANDS IMPOSED ON A SURFACE TENSION PROPELLANT TANK DUE TO REFUELLABILITY IN THE MICROGRAVITY ENVIRONMENT OF OUTER SPACE [ANFORDERUNGEN AN OBERFLAECHENSPANNUNGSTANKS DURCH DIE WIEDERBETANKBARKEIT IM WELTRAUM UNTER SCHWERELOSIGKEIT]
G. NETTER and U. RENNER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 35-44. In German. refs
(DGLR PAPER 86-104)

The present status of refuelling in orbit is summarized, and problems of refuelling a surface-tension propellant tank in orbit are discussed. The physics of refilling the tank is briefly presented, and the ways that various types of tanks approach problems related to refuelling are considered, examining fuel inflow systems and tank components. Areas in which further technological development is needed are addressed, indicating present analytical and experimental undertakings and planned projects.
C.D.

A87-38001#
ELECTRIC PROPULSION FOR ORBIT TRANSFER - A NAVSTAR CASE STUDY (HAS ELECTRIC PROPULSION'S TIME COME?)
JESS M. SPONABLE (USAF, Washington, DC) and JAY P. PENN (Aerospace Corp., El Segundo, CA) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 12 p.
(AIAA PAPER 87-0985)

This study assesses the viability and cost of using electric propulsion to transfer future global positioning system satellites from shuttle parking orbits to mission orbits. Transportation-to-orbit life cycle costs of a xenon-ion and ammonia arcjet-propelled electric-orbital transfer vehicle (EOTV) are compared to those of a conventional (PAM-DII) chemical upper stage currently on contract. Use of the EOTV in lieu of this upper stage can potentially reduce the Space Shuttle cargo element mass by 73 percent and the transport to orbit life cycle cost by as much as 61 percent, or $21 million per flight while still meeting a 90-day flight time requirement.
Author

A87-38003#
THE USE OF ELECTRIC PROPULSION ON LOW EARTH ORBIT SPACECRAFT
A. R. MARTIN and M. T. CRESDEE (Culham Laboratory, Abingdon, England) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 10 p. Research supported by the British National Space Centre. refs
(AIAA PAPER 87-0989)

In the past, in the United Kingdom the analysis of missions for electric propulsion systems has been concerned with north-south station keeping of a satellite in a geostationary orbit, orbit raising of spacecraft from low earth orbit to geostationary orbit, and interplanetary missions to regions of the solar system outside the gravitational influence of the earth. A further class of mission not discussed as yet is the application of electric propulsion to systems operating in low earth orbit, and this is the subject of the present paper. In particular, the different elements of the United States of America/International Space Station are considered. This is appropriate at the present time as a result of the European Columbus activities on the various station elements.
Author

A87-38004*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

GEOSYNCHRONOUS EARTH ORBIT BASE PROPULSION - ELECTRIC PROPULSION OPTIONS

B. PALASZEWSKI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 13 p. refs
(AIAA PAPER 87-0990)

Electric propulsion and chemical propulsion requirements for a geosynchronous earth orbit (GEO) base were analyzed. The base is resupplied from the Space Station's low earth orbit. Orbit-transfer Delta-Vs, nodal-regression Delta-Vs and orbit-maintenance Delta-Vs were considered. For resupplying the base, a cryogenic oxygen/hydrogen (O2/H2) orbital transfer vehicle (OTV) is currently-baselined. Comparisons of several electric propulsion options with the O2/H2 OTV were conducted. Propulsion requirements for missions related to the GEO base were also analyzed. Payload data for the GEO missions were drawn from current mission data bases. Detailed electric propulsion module designs are presented. Mission analyses and propulsion analyses for the GEO-delivered payloads are included. Author

A87-38015#

A UK LARGE DIAMETER ION THRUSTER FOR PRIMARY PROPULSION

A. R. MARTIN, A. BOND, K. E. LAVENDER, M. S. HARVEY, and P. M. LATHAM (Culham Laboratory, Abingdon, England) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 10 p. Research supported by the British National Space Centre. refs
(AIAA PAPER 87-1031)

Attention is given to recent research efforts in the UK concerning the use of ion thrusters for orbit-raising of LEO platforms, for large spacecraft drag compensation, and for general space system control and positioning tasks; these applications require thrust levels of a few hundred mN. Development work has accordingly concentrated on a 25-cm diameter Kaufman-type ion thruster with a nominal output of 200 mN, using Xe as a propellant. Initial test results are presented. O.C.

A87-38016#

CP/MPS - CONTAINED PLASMA MAGNETIC PROPULSION SYSTEM: AN ADVANCED PROPULSION CONCEPT

J. M. MCCANNEY (Satellite Technology, Inc., Saint Paul, MN) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 8 p. Research supported by Satellite Technology, Inc. refs
(AIAA PAPER 87-1042)

A new concept for an electric propulsion system is presented which combines small physical size with high current densities to produce usable propulsion for satellite docking, remote manipulation of satellites and sensitive payloads, station keeping, space tug or orbital transfer (OTV) and for a transatmospheric vehicle (TAV) which is gyro-stabilized. The design has evolved over the past five years to its present state. The concept is described and placed into perspective with state of the art MPD and electric propulsion devices. Author

A87-38569* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ELECTRODYNAMIC PLASMA MOTOR/GENERATOR EXPERIMENT

JAMES E. MCCOY (NASA, Johnson Space Center, Houston, TX) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986. San Diego, CA, Univelt, Inc., 1987, p. 91-115.
(AAS PAPER 86-210)

The Plasma Motor/Generator Proof of Function (PMG/POF) experiment, a low-cost payload for flight aboard the Shuttle Orbiter using the Hitchhiker G carrier, is discussed. The primary objective of this experiment is to verify that hollow cathode plasma sources can couple electric currents from either end of a long wire moving through the space plasma in LEO into and through that plasma to produce a PMG circuit. The support structure and the electrical components of the experiment are described. The experimental operation is discussed, including the calibration, experimental measurements, and follow-on missions. C.D.

A87-38572* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

PLASMA MOTOR/GENERATOR REFERENCE SYSTEM DESIGNS FOR POWER AND PROPULSION

JAMES E. MCCOY (NASA, Johnson Space Center, Houston, TX) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986. San Diego, CA, Univelt, Inc., 1987, p. 439-452.
(AAS PAPER 86-229)

Four Plasma Motor/Generator (PMG) Reference Systems, hollow cathode-based versions of the electrodynamic tether concept which are to be used in study and analysis of future propulsion and power applications, are discussed. These systems are equally applicable for use as electric generators to provide power to a spacecraft or as electric motors using power from the spacecraft. Operating at relatively high current and low voltage, the PMGs avoid requirements for technological advances to handle very high voltages. Permanent deployment with passive I x B control of tether dynamics eliminates the complexity and weight of a TSS style tether reel. A 20 kW PMG uses 10 km of number two aluminum wire, weighs 1200 kg, and has an electrical efficiency of 93 percent. A larger 200 kW system uses 20 km of number 00 aluminum wire, weighs 4200 kg, and operates at 87 percent efficiency. C.D.

A87-38776* Hamilton Standard, Windsor Locks, Conn.

MAINTENANCE COMPONENTS FOR SPACE STATION LONG LIFE FLUID SYSTEMS

JOHN B. GREENE, JR., GEORGE J. ROEBELEN, JR. (United Technologies Corp., Hamilton, Standard Div., Windsor Locks, CT), and JAMES W. OWEN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986. Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 825-833.
(SAE PAPER 861005)

The Space Station elements or modules will maintain thermal conditioning by way of fluid systems. Because of the Station's 20 year minimum orbital lifetime, these fluid system designs must allow for on-orbit maintenance. This paper describes the maintenance assessment of the various Space Station thermal control system options, their components and the recommended maintenance approach for each. The design and utilization of the primary fluid isolation servicing method, the Maintainable Maintenance Disconnect Valve (MMDV) and the effects of selecting different levels for the orbital replacement unit (ORU) are also presented. Author

A87-38785

SYMPOSIUM ON MICROGRAVITY FLUID MECHANICS, PROCEEDINGS OF THE WINTER ANNUAL MEETING, ANAHEIM, CA, DEC. 7-12, 1986

D. J. NORTON, ED. (Houston Area Research Center, TX) Symposium sponsored by ASME. New York, American Society of Mechanical Engineers, 1986, 77 p. For individual items see A87-38786 to A87-38797.

Papers are presented on the development of two-phase computer codes for microgravity applications, diffusion flame extinction in slow convective flow under microgravity environment, a differential approach to heat pipe priming in microgravity, an experimental study using flow visualization on the effect of an acoustic field on heat transfer, and equilibrium fluid interfaces in the absence of gravity. Consideration is given to microcirculatory fluid dynamics in weightlessness and simulated weightlessness, zero-G fluid mechanics in animals and man, cardiovascular adaptation to zero-G, microgravity-induced fluid and electrolyte balance changes, and continuous flow electrophoresis in microgravity. Additional papers are on Space Station fluid management systems, low-G fluid motion test and analysis, the transient flow analysis and testing of the Space Shuttle Reaction Control System's low-G propellant acquisition system, and propellant tank forces resulting from fluid motion in a low-gravity field. I.S.

A87-41122#

1987 STATUS REPORT - UNITED STATES AIR FORCE ELECTRIC PROPULSION RESEARCH AND DEVELOPMENT

ROBERT D. MEYA and TONY H. Q. NGUYEN (USAF, Astronautics Laboratory, Edwards AFB, CA) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 14 p. refs
(AIAA PAPER 87-1036)

The Air Force Astronautics Laboratory (AFAL) is currently developing electric propulsion technology to meet USAF and DOD requirements for military space missions. The AFAL's three-tiered R&D program is presented. In order of priority, the first tier is the space demonstration of a space-qualified 30-kWe-class arcjet propulsion system, while the second tier is the continued industrial development of arcjet technology to increase specific impulse and lifetime; the third tier is the continued university development of steady-state multimegawatt MPD thrusters to guarantee the availability of MPD technology upon USAF deployment of operational multimegawatt space power supplies. K.K.

A87-41575* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ADVANCED PROPULSION ACTIVITIES IN THE USA

P. W. GARRISON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (IAF, International Astronautical Congress on Space: New Opportunities for all People, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, p. 357-366. refs

An evaluation is made of technology development prospects for launch vehicle, orbit transfer vehicle, satellite, and planetary exploration spacecraft propulsion systems being contemplated by NASA and its research contractors. Attention is given to such electric propulsion systems as arcjet, pulsed plasma, ion, and resistojet thrusters, as well as to solar thermal heat exchanger powerplants, beamed energy propulsion systems, and ultra-advanced nuclear fission and fusion propulsion concepts. O.C.

A87-41615*# Colorado Univ., Boulder.

INADEQUACY OF SINGLE-IMPULSE TRANSFERS FOR PATH CONSTRAINED RENDEZVOUS

S. A. STERN (Colorado, University, Boulder) and K. M. SOILEAU (NASA, Johnson Space Center, Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, May-June 1987, p. 282-284. refs

The use of single-impulse techniques to maneuver from point to point about a large space structure (LSS) with an arbitrary geometrical configuration and spin is examined. Particular consideration is given to transfers with both endpoints on the forbidden zone surface. Clohessy-Wiltshire equations of relative motion are employed to solve path constrained rendezvous problems. External and internal transfers between arbitrary points are analyzed in terms of tangential departure and arrival conditions. It is observed that single-impulse techniques are inadequate for transferring about the exterior of any LSS; however, single-impulse transfers are applicable for transfers in the interior of LSSs. It is concluded that single-impulse transducers are not applicable for path constrained rendezvous guidance. I.F.

A87-42680

STATUS AND TENDENCIES FOR LOW TO MEDIUM THRUST PROPULSION SYSTEMS

HELMUT HOPMANN, RICHARD PITT, MANFRED SCHWENDE, and HELMUT ZEWEN (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 37 p. refs
(IAF PAPER 86-162; MBB-UR-877-86-PUB)

A review of ESA's goals through the year 2020 reveals that the category of low to medium thrust propulsion systems will be of major importance in the future. Propulsion systems for satellites and probes are considered as well as those for orbital maneuvering and transfer vehicles. Space Station programs like Columbus will require longer life components and increased modularity while manned launch vehicles such as Ariane V with Hermes or space planes such as HOTOL will demand higher safety and reliability requirements as well as maximum reuseability. K.K.

A87-43027*# General Dynamics Corp., San Diego, Calif.

EVALUATION OF CRYOGENIC SYSTEM TEST OPTIONS FOR THE OTV ON-ORBIT PROPELLANT DEPOT

JOHN R. SCHUSTER, T. JAMES ALTON (General Dynamics Corp., Space Systems Div., San Diego, CA), NORMAN S. BROWN, and UWE HUETER (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 12 p.
(AIAA PAPER 87-1498)

Future space missions to geosynchronous, lunar, and planetary orbits will require an orbital depot for stockpiling propellants. This depot will provide long-term storage of cryogens, requiring new technologies for fluid management in microgravity and further development of thermal management technologies for minimization of cryogen boiloff. Preliminary evaluations have been made to define a test program approach for reducing technical risk through verifying performance models and building a base of engineering data for depot design. A number of testing options were defined and evaluated, leading to selection of ground testing combined with an orbital systems test. Ground testing is inadequate because of critical microgravity concerns; extending testing aboard the Space Station was eliminated because the data would not be available soon enough to benefit the propellant depot design. The orbital test would either be a short-term test carried out in the cargo bay of the Space Shuttle Orbiter using a nonhazardous cryogen or a longer term test carried out with hydrogen aboard a free-flying experiment orbited with an expendable launch vehicle. Author

A87-44832#

ON-ORBIT CRYOGENIC FLUID MANAGEMENT EXPERIMENTAL DATA REQUIREMENTS USING REFEREE FLUIDS

R. S. RUDLAND (Martin Marietta Corp., Denver, CO) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 6 p.
(AIAA PAPER 87-1559)

A review of testing requirements for cryogenic fluid management designs in space show that liquid nitrogen and liquid helium can be used in a limited way to obtain data for liquid oxygen and liquid hydrogen fluid tanker designs. Current testing at Martin Marietta with liquid nitrogen is useful for developing experience with cryogenic transfer concepts. Many tests are still needed on the ground, in drop tower tests, in the KC-135, and in space to eliminate weaknesses in the fluid transfer system design. Author

A87-45190#

MODELING OF FLUID TRANSFER IN ORBIT

IN-KUN KIM and F. O. BENNETT, JR. (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 6 p. refs
(AIAA PAPER 87-1763)

Transfer of cryogenic propellants in orbit using a total communication, surface tension liquid acquisition device (LAD) has been analytically modeled. The LAD is a symmetrical, four-channel, screen-covered system feeding a collector manifold at the tank outlet. In the present study, the computer program optimizes the acquisition channels based on an assumed acquisition rate and estimates total time required for transfer. The model addresses such previously unreported issues as channel sizing, effect of liquid 'uncovering' screen surfaces, effect of diffuser location, etc. The program uses a model of the instantaneous relationship between uncovered screen area and tank ullage volume. The study demonstrates that a channel/screen-type LAD can be sized and optimized if the acquisition requirements and constraints are known. Author

A87-45191* Boeing Aerospace Co., Seattle, Wash.
SPACE-BASED OTV BOILOFF DISPOSITION
C. L. WILKINSON (Boeing Aerospace Co., Seattle, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 7 p.
(Contract NAS8-36107)
(AIAA PAPER 87-1767)

The boiloff and chilldown problem associated with a reusable space-based orbital transfer vehicle (OTV) that uses the Space Station as a base of operations is considered. Various boiloff and chilldown gas disposal options are examined, and a recommended approach is defined on the basis of least life-cycle cost. In accordance with this approach, half of the gaseous hydrogen is used to generate 3.87 kW, while the remaining hydrogen and the resulting water are remotely vented using the Orbital Maneuvering Vehicle. V.L.

A87-45196#
HYDROGEN-OXYGEN THRUSTER WITH NO PRODUCTS OF COMBUSTION IN EXHAUST PLUME
GREGORY S. HOSFORD and KEN CLODFELTER (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 4 p.
(AIAA PAPER 87-1775)

A bipropellant jet thruster concept is proposed which has a high specific impulse without the disadvantages of combustion products in the exhaust gas stream or the weight penalties of electrical energy storage. It is shown how the present concept can be integrated with an electrolyzer reactant supply system such as the one proposed for the Space Station. The clean effluent jet in this application has the benefit of no net oxygen consumption because all the oxygen is contained in the water combustion product, which is captured and recirculated to the reactant supply system. R.R.

A87-45255*# Rockwell International Corp., Canoga Park, Calif.
SPACE STATION PROPULSION SYSTEM TEST BED AND CONTROL SYSTEM TESTING RESULTS
A. M. NORMAN, G. L. BRILEY, L. H. NAVE, J. F. PAVLINSKY (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), and S. ALLUMS (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 12 p.
(Contract NAS8-36418)
(AIAA PAPER 87-1858)

The test bed fabricated to demonstrate hydrogen/oxygen propulsion technology readiness for the IOC Space Station application is described and test results are presented. The reliability and safety of the O2/H2 system was demonstrated with blowdowns and thruster firings. The flexibility of the system was demonstrated through the addition of an electrolysis supply module. K.K.

A87-45256*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONCEPTUAL DESIGN AND INTEGRATION OF A SPACE STATION RESISTOJET PROPULSION ASSEMBLY
R. R. TACINA (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 13 p. Previously announced in STAR as N87-20378. refs
(AIAA PAPER 87-1860)

The resistojet propulsion module is designed as a simple, long life, low risk system offering operational flexibility to the space station program. It can dispose of a wide variety of typical space station waste fluids by using them as propellants for orbital maintenance. A high temperature mode offers relatively high specific impulse with long life while a low temperature mode can propulsively dispose of mixtures that contain oxygen or hydrocarbons without reducing thruster life or generating particulates in the plume. A low duty cycle and a plume that is confined to a small aft region minimizes the impacts on the users. Simple interfaces with other space station systems facilitate integration. It is concluded that there are no major obstacles and many advantages to developing, installing, and operating a resistojet propulsion module aboard the Initial Operational Capability (IOC) space station. Author

A87-45259*# Booz-Allen and Hamilton, Inc., Washington, D. C.
THE IMPACT OF INTEGRATED WATER MANAGEMENT ON THE SPACE STATION PROPULSION SYSTEM
GEORGE R. SCHMIDT (Booz-Allen and Hamilton, Inc., Washington, DC) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 9 p.
(Contract NAS8-36526)
(AIAA PAPER 87-1864)

The water usage of elements in the Space Station integrated water system (IWS) is discussed, and the parameters affecting the overall water balance and the water-electrolysis propulsion-system requirements are considered. With nominal IWS operating characteristics, extra logistic water resupply (LWR) is found to be unnecessary in the satisfaction of the nominal propulsion requirements. With the consideration of all possible operating characteristics, LWR will not be required in 65.5 percent of the cases, and for 17.9 percent of the cases LWR can be eliminated by controlling the stay time of the Shuttle Orbiter. R.R.

A87-45260#
ANALYTICAL AND EXPERIMENTAL MODELING OF ZERO/LOW GRAVITY FLUID BEHAVIOR
TSO-PING YEH (Ford Aerospace and Communications Corp., Palo Alto, CA) and GEORGE F. ORTON (McDonnell Douglas Corp., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 8 p.
(AIAA PAPER 87-1865)

A combined analytical and experimental study has been conducted to develop methods to predict the fluid behavior under zero/low-gravity conditions. Analytical models to predict stable equilibrium liquid free surface shape, transient liquid reorientation characteristics, liquid pumping capability of various channel configuratins, and liquid settling and slosh dynamics are presented. Experimental methods (zero-gravity drop tower and KC-135 airplane flight tests) used to simulate the fluid behavior are also discussed. Good agreement was found between the analytical models and the test data. The analytical models and the fundamental zero-gravity fluid behavior data are critical to the design of advanced fluid management systems and point sensor propellant gaging systems for space vehicles. Author

A87-45287#
SPACE STATION OPTIONS FOR CONSTRUCTING ADVANCED SOLAR SAILS CAPABLE OF MULTIPLE MARS MISSIONS
J. M. GARVEY (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 9 p. refs
(AIAA PAPER 87-1902)

This paper considers the potential for using a Space Station in low earth orbit to build reusable solar sails that are capable of delivering significanat payloads to Mars. Operationally, the use of a long (10-150 km) tether provides a method for overcoming the obstacles of atmospheric drag, interference with the Space Station, logistics, and placement of the finished sail into a functional orbit. Because the sails are designed for and built in space, they have a much higher performance than earth-launched versions, which must also tolerate the harsher regimes associated with packaging, launch, and deployment. The sail baselined in this paper can deliver over thirty metric tons of payload to Mars during close approach. Author

A87-45311#

LIQUID PROPULSION TECHNOLOGY FOR EXPENDABLE AND STS LAUNCH VEHICLE TRANSFER STAGES

KIMBERLY A. ENNIX and MARK COLEMAN (USAF, Astronautics Laboratory, Edwards AFB, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 6 p.

(AIAA PAPER 87-1934)

Liquid propulsion design options for orbital transfer vehicles (OTV) were analyzed for various upper stage applications. High and low pressure earth storable propellant system technology and high performance, low thrust cryogenic concepts were investigated for payload stages of 39,000 lbm to 57,300 lbm low earth orbit (LEO) class launch vehicles. The design criteria was baselined for a specific impulse of 340 seconds and mass fraction of 0.90 with LEO altitude of 110 nm. Performance results were computed for a range of mass fraction between 0.88 and 0.92 and ISP between 320 and 500 seconds. Author

A87-45357#

MIXING-INDUCED ULLAGE CONDENSATION AND FLUID DESTRATIFICATION

JERE S. MESEROLE, OGDEN S. JONES, SCOTT M. BRENNAN, and ANTHONY FORTINI (Boeing Aerospace Co., Seattle, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 12 p. refs

(AIAA PAPER 87-2018)

Forced mixing may be required for on-orbit storage and transfer of cryogens. To provide applicable data on jet-induced mixing, an experiment was conducted in which an axial jet mixer promoted condensation of the ullage and lowered the pressure in a subscale cylindrical tank partially filled with Freon 11. The test objectives were to (1) determine the transient condensation and heat transfer rates at the liquid-vapor interface as a function of jet parameters, (2) quantify the important factors affecting mixing efficiency, and (3) compare mixing times to previous mixing data based on acid-base neutralization and dye dispersion. The variation of interface heat transfer coefficient with changes in jet Reynolds number was consistent with existing correlations based on measurements of steady-state rates of mixing-induced condensation of steam. Mixing times based on tank pressure decay were correlated with jet momentum flux, although buoyancy effects made it difficult to extrapolate all the results to low gravity. Mixers with large diameter nozzles and low flow rates required the most time and least amount of energy to destratify the fluid. Dimensionless mixing times agreed with comparable acid-base neutralization data, but not with dye dispersion data. Author

A87-45360#

LIQUID PROPELLANT TANK ULLAGE BUBBLE DEFORMATION AND BREAKUP IN LOW GRAVITY REORIENTATION

JAMES J. DER and CHRISTINE L. STEVENS (Aerospace Corp., Los Angeles, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 9 p. refs

(Contract F04701-85-C-0086-P00016)

(AIAA PAPER 87-2021)

Collapse, geyser formation, and breakup of a reorienting ullage bubble in liquid propellant tanks under low gravity have been studied numerically. The response of liquid propellant in a partially filled spacecraft tank under a suddenly imposed external acceleration has been examined. The similitude variables developed in a previous paper for correlating unsteady numerical and experimental data of the bubble motion are applicable here for the kinetics of the bubble surface. When the bubble is initially situated further from the new top surface, some of the energy is dissipated in fragmenting the bubble. Also, there is more liquid between the bubble and the wall. Thus, the further the initial location of the ullage is from the new top, the weaker the liquid jet striking the wall. For the case of larger ullage, there is less liquid participation in the geyser formation, and the jet is therfore weaker. With an ullage as large as 30 percent, the geyser can at most barely penetrate the bubble. Author

A87-45439#

NERVA DERIVED NUCLEAR ORBIT TRANSFER SYSTEM

TAL K. SULMEISTERS (Martin Marietta Corp., Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 6 p.

(AIAA PAPER 87-2155)

A version of the NERVA nuclear rocket engine is compared to a chemical system in terms of mission applications and costs. A space transportation architecture study mission model was used to evaluate mission applications; the missions included integral, orbit maneuvering vehicle, orbit transfer vehicle, and planetary. The stage design and operation are discussed. Radiation decay levels were examined; it is determined that radiation levels are within acceptable levels for unmanned and manned operations. The life cycle costs for the nuclear and chemical orbit transfer systems are analyzed. The effects of variations in payload weight, stage weight, stage performance, and costs on nuclear and chemical stages are investigated. The data reveal that the nuclear stage is safer, and more efficient and reliable at a lower cost, than the chemical stage for the same mission. I.F.

A87-48572*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMODYNAMIC ANALYSIS AND SUBSCALE MODELING OF SPACE-BASED ORBIT TRANSFER VEHICLE CRYOGENIC PROPELLANT RESUPPLY

DAVID M. DEFELICE and JOHN C. AYDELOTT (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 21 p. Previously announced in STAR as N87-22949. refs

(AIAA PAPER 87-1764)

The resupply of the cryogenic propellants is an enabling technology for spacebased orbit transfer vehicles. As part of the NASA Lewis ongoing efforts in microgravity fluid management, thermodynamic analysis and subscale modeling techniques were developed to support an on-orbit test bed for cryogenic fluid management technologies. Analytical results have shown that subscale experimental modeling of liquid resupply can be used to validate analytical models when the appropriate target temperature is selected to relate the model to its prototype system. Further analyses were used to develop a thermodynamic model of the tank chilldown process which is required prior to the no-vent fill operation. These afforts were incorporated into two FORTRAN programs which were used to present preliminary analytical results. Author

A87-49615*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SYNERGETIC PLANE-CHANGE CAPABILITY OF A CONCEPTUAL AEROMANEUVERING-ORBITAL-TRANSFER VEHICLE

GENE P. MENEES (NASA, Ames Research Center, Moffett Field, CA), JOHN F. WILSON (Sterling Software, Palo Alto, CA), and HENRY G. ADELMAN (Eloret Institute, Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 388-397. refs

(AIAA PAPER 87-2565)

The flight strategy for a general low-earth orbit plane-change is analyzed for a conceptual, high-lift, aeromaneuvering-orbital-transfer vehicle, and applied to the important case of the 45 deg plane-inclination change. The study focuses on two principle methods: (1) the procedure to obtain a change in the inclination of the vehicle's orbital plane, and (2) the full rendezvous procedure. Optimal trajectories for minimal propellant use during the synergetic aerotransit are developed, which incorporate best estimates of constraints imposed by reusable thermal-protection requirements and human tolerance to g-load levels. The performance capability for one-way payload delivery to the target orbit is analyzed in detail and the capability for return to the base orbit demonstrated. Author

A87-49617#

COMBINING SPACE-BASED PROPULSIVE MANEUVERS AND AERODYNAMIC MANEUVERS TO ACHIEVE OPTIMAL ORBITAL TRANSFER

JOHN M. HANSON (Anser, Space Systems Div., Arlington, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 406-416. refs
(AIAA PAPER 87-2567)

This paper presents solutions to the problem of optimal atmospheric turning. The main purpose, however, is to demonstrate how much the required velocity change can be reduced by combining aerodynamic and propulsive maneuvers during the orbital transfer. Comparisons are given for purely propulsive maneuvers, maneuvers using aerodrag only (no lift), maneuvers with all plane change occurring in the atmosphere, and maneuvers combining atmospheric and propulsive impulses optimally to achieve minimum velocity change requirements. Results are presented for vehicles with a range of maximum lift-to-drag ratios. All cases are for transfers between circular orbits. Author

A87-50197*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY PERFORMANCE CHARACTERIZATIONS OF AN ENGINEERING MODEL MULTIPROPELLANT RESISTOJET FOR SPACE STATION APPLICATION

W. EARL MORREN, THOMAS W. HAAG, JAMES S. SOVEY (NASA, Lewis Research Center, Cleveland, OH), and STUART S. HAY (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 24 p. Previously announced in STAR as N87-23821. refs
(AIAA PAPER 87-2120)

Presented are the results of a program to describe the operational characteristics of an engineering model multipropellant resistojet for application as an auxiliary propulsion system for the space station. Performance was measured on hydrogen, helium, methane, water (steam), nitrogen, air, argon, and carbon dioxide. Thrust levels ranged from 109 to 355 mN, power levels ranged from 167 to 506 W, and specific impulse values ranged from 93 to 385 sec, depending on the propellant, chamber pressure, and heater current level selected. Detailed thermal maps of the heater and heat exchanger were also obtained for operation with carbon dioxide. Author

A87-50509*# Washington State Univ., Pullman.

AEROASSISTED ORBITAL MANEUVERING USING LYAPUNOV OPTIMAL FEEDBACK CONTROL

WALTER J. GRANTHAM (Washington State University, Pullman) and BYOUNG-SOO LEE IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 994-1000. refs
(Contract NCA2-191)
(AIAA PAPER 87-2464)

A Liapunov optimal feedback controller incorporating a preferred direction of motion at each state of the system which is opposite to the gradient of a specified descent function is developed for aeroassisted orbital transfer from high-earth orbit to LEO. The performances of the Liapunov controller and a calculus-of-variations open-loop minimum-fuel controller, both of which are based on the 1962 U.S. Standard Atmosphere, are simulated using both the 1962 U.S. Standard Atmosphere and an atmosphere corresponding to the STS-6 Space Shuttle flight. In the STS-6 atmosphere, the calculus-of-variations open-loop controller fails to exit the atmosphere, while the Liapunov controller achieves the optimal minimum-fuel conditions, despite the + or - 40 percent fluctuations in the STS-6 atmosphere. R.R.

A87-52247*# Washington Univ., St. Louis, Mo.

TEMPERATURE FIELDS DUE TO JET INDUCED MIXING IN A TYPICAL OTV TANK

J. I. HOCHSTEIN, HYUN-CHUL JI (Washington University, Saint Louis, MO), and J. C. AYDELOTT (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 11 p. refs
(Contract NAG3-578)
(AIAA PAPER 87-2017)

The Eclipse Code is being developed as a general tool for analysis of cryogenic propellant behavior in spacecraft tankage. The focus of the work being reported is on prediction of temperature fields due to introduction of a cold jet along the centerline of a typical Orbit Transfer Vehicle tank. A brief description of the formulations used for modeling heat transfer and turbulent flow is presented. Code performance is verified through comparison to experimental data for mixing in small scale tanks. An unexpected difficulty in computing long duration flows is reviewed. Preliminary results for a partially filled full scale tank are obtained by approximating the free surface by a spherical solid boundary. Author

A87-54196

ION THRUSTERS ADVANCE

ANDREW WILSON Space (ISSN 0267-954X), vol. 3, July-Aug. 1987, p. 18, 19.

The development of ion engines for future space missions is discussed. The use of a 10-cm ion thruster system for satellite stationkeeping, the 25-cm thruster for the Comet Nucleus Sample Return mission, and the new xenon test facility are examined. Ion thrusters are applicable to geostationary comsats, the Columbus Polar Platform, the coorbiting platforms of the Space Station, and deep-space missions. A diagram of the T4 mercury thruster is presented. I.F.

N87-20375 Department of the Air Force, Washington, D.C.

PROPELLANT TANK RESUPPLY SYSTEM Patent

THOMAS F. SCHWEICKERT, inventor (to Air Force) and GEORGE F. ORTON, inventor (to Air Force) 2 Sep. 1986 5 p Supersedes N85-13848, AD-D011288 (83 - 05, p 603)
(AD-D012559; US-PATENT-4,609,169;
US-PATENT-APPL-SN-640636) Avail: US Patent and Trademark Office CSCL 21I

The present invention relates generally to improvements in attitude control systems (ACS) for spacecraft and more particularly to a novel propellant tank resupply system and method for increasing ACS propellant usage capability through resupply of the ACS tanks during operation of the engines of the primary propulsion system. GRA

N87-20378*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONCEPTUAL DESIGN AND INTEGRATION OF A SPACE STATION RESISTOJET PROPULSION ASSEMBLY

ROBERT R. TACINA 1987 19 p Prepared for presentation at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 21 Jul. 1987; sponsored in part by AIAA, SAE, ASME and ASEE
(NASA-TM-89847; E-3483; NAS 1.15:89847) Avail: NTIS HC A02/MF A01 CSCL 21H

The resistojet propulsion module is designed as a simple, long life, low risk system offering operational flexibility to the space station program. It can dispose of a wide variety of typical space station waste fluids by using them as propellants for orbital maintenance. A high temperature mode offers relatively high specific impulse with long life while a low temperature mode can propulsively dispose of mixtures that contain oxygen or hydrocarbons without reducing thruster life or generating particulates in the plume. A low duty cycle and a plume that is confined to a small aft region minimizes the impacts on the users.

Simple interfaces with other space station systems facilitate integration. It is concluded that there are no major obstacles and many advantages to developing, installing, and operating a resistojet propulsion module aboard the Initial Operational Capability (IOC) space station. Author

N87-21141*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MICROGRAVITY FLUID MANAGEMENT SYMPOSIUM
Apr. 1987 225 p Symposium held in Cleveland, Ohio, 9-10 Sep. 1986
(NASA-CP-2465; E-3386; NAS 1.55:2465) Avail: NTIS HC A10/MF A01 CSCL 22A

The NASA Microgravity Fluid Management Symposium, held at the NASA Lewis Research Center, September 9 to 10, 1986, focused on future research in the microgravity fluid management field. The symposium allowed researchers and managers to review space applications that require fluid management technology, to present the current status of technology development, and to identify the technology developments required for future missions. The 19 papers covered three major categories: (1) fluid storage, acquisition, and transfer; (2) fluid management applications, i.e., space power and thermal management systems, and environmental control and life support systems; (3) project activities and insights including two descriptions of previous flight experiments and a summary of typical activities required during development of a shuttle flight experiment.

N87-21142*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ADVANCED LONG TERM CRYOGENIC STORAGE SYSTEMS
NORMAN S. BROWN *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 7-16 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22B

Long term, cryogenic fluid storage facilities will be required to support future space programs such as the space-based Orbital Transfer Vehicle (OTV), Telescopes, and Laser Systems. An orbital liquid oxygen/liquid hydrogen storage system with an initial capacity of approximately 200,000 lb will be required. The storage facility tank design must have the capability of fluid acquisition in microgravity and limit cryogen boiloff due to environmental heating. Cryogenic boiloff management features, minimizing Earth-to-orbit transportation costs, will include advanced thick multilayer insulation/integrated vapor cooled shield concepts, low conductance support structures, and refrigeration/reliquefaction systems. Contracted study efforts are under way to develop storage system designs, technology plans, test article hardware designs, and develop plans for ground/flight testing. Author

N87-21143*# General Dynamics Corp., San Diego, Calif. Space Systems Div.
LONG TERM CRYOGENIC STORAGE FACILITY SYSTEMS STUDY
JOHN R. SCHUSTER *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 17-30 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22B

The Long Term Cryogenic Storage Facility Systems Study (LTCSFSS) is a Phase A study of a large capacity propellant depot for the space based, cryogenic orbital transfer vehicle. The study is being performed for Marshall Space Flight Center by General Dynamics Space Systems Division and has five principal objectives: (1) Definition of preliminary concept designs for four storage facility concepts; (2) Selection of preferred concepts through the application of trade studies to candidate propellant management system components; (3) Preparation of a conceptual design for an orbital storage facility; (4) Development of supporting research and technology requirements; and (5) Development of a test program to demonstrate facility performance. The initial study has been completed, and continuation activities are just getting under way to provide greater detail in key areas and accommodate changes in study guidelines and assumptions. Author

N87-21144*# Beech Aircraft Corp., Boulder, Colo.
SPACE STATION EXPERIMENT DEFINITION: LONG TERM CRYOGENIC FLUID STORAGE
DAVID H. RIEMER *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 31-42 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22B

A preliminary design of an experiment to demonstrate and evaluate long-term cryogenic fluid storage and transfer technologies has been performed. This Long-Term Cryogenic Fluid Storage (LTCFS) experiment is a Technology Development Mission (TDM) experiment proposed by the NASA Lewis Research Center to be deployed on the Initial Operational Capability (IOC) space station. Technologies required by future orbital cryogenic systems such as Orbital Transfer Vehicles (OTV's) were defined, and critical technologies requiring demonstration were chosen to be included in the experiment. A three-phase test program was defined to test the following types of technologies: (1) Passive Thermal Technologies; (2) Fluid Transfer Technologies; and (3) Active Refrigeration Technologies. The development status of advanced technologies required for the LTCFS experiment is summarized, including current, past and future programs. Author

N87-21145*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HELIUM TECHNOLOGY ISSUES
PETER KITTEL *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 43-55 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

A number of future space missions require liquid helium for cooling scientific payloads. These missions will require the long term storage and resupply of liquid helium at temperatures of 1.4 - 2.1 Kelvin. In addition, some of the proposed instruments will require refrigeration to temperatures as low as 50 mK. A variety of liquid helium based refrigerator systems could provide this subkelvin cooling. The status of helium storage and refrigeration technologies and of several alternative technologies is presented here along with areas where further research and development are needed. (Helium resupply technologies are the topic of another presentation at this symposium). The technologies covered include passive and dynamic liquid helium storage, alternatives to liquid helium storage, He -3 refrigerators, He -3/He -4 dilution refrigerators, and alternative sub-kelvin coolers. Author

N87-21146*# Boeing Aerospace Co., Seattle, Wash.
OVERVIEW: FLUID ACQUISITION AND TRANSFER
JERE S. MESEROLE *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 57-65 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

This brief overview introduced the symposium session on microgravity fluid acquisition and transfer. It states the objective of NASA efforts in this technology and the approach being taken in the technology program. The problems are outlined and various methods for low-gravity fluid acquisition and transfer are summarized. Applications for the technology are described and an assessment of the current state of the art is presented. NASA and DOD on-going and planned programs are listed. Author

N87-21147*# Massachusetts Inst. of Tech., Cambridge.
THE COUPLED DYNAMICS OF FLUIDS AND SPACECRAFT IN LOW GRAVITY AND LOW GRAVITY FLUID MEASUREMENT
R. JOHN HANSMAN, LEE D. PETERSON, and EDWARD F. CRAWLEY *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 67-84 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

The very large mass fraction of liquids stored on broad current and future generation spacecraft has made critical the technologies of describing the fluid-spacecraft dynamics and measuring or gauging the fluid. Combined efforts in these areas are described, and preliminary results are presented. The coupled dynamics of fluids and spacecraft in low gravity study is characterizing the parametric behavior of fluid-spacecraft systems in which interaction between the fluid and spacecraft dynamics is encountered. Particular emphasis is given to the importance of nonlinear fluid free surface phenomena to the coupled dynamics. An experimental apparatus has been developed for demonstrating a coupled fluid-spacecraft system. In these experiments, slosh force signals are fed back to a model tank actuator through a tunable analog second order integration circuit. In this manner, the tank motion is coupled to the resulting slosh force. Results are being obtained in 1-g and in low-g (on the NASA KC-135) using dynamic systems nondimensionally identical except for the Bond numbers. Author

N87-21148*# Washington Univ., St. Louis, Mo.
NUMERICAL MODELLING OF CRYOGENIC PROPELLANT BEHAVIOR IN LOW-G
JOHN I. HOCHSTEIN *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 85-100 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

A partial survey is presented of recent research, sponsored by the NASA Lewis Research Center, into the computational modelling of cryogenic propellant behavior in a low gravity environment. This presentation is intended to provide insight into some of the specific problems being studied and into how these studies are part of an integrated plan to develop predictive capabilities. A brief description of the computational models developed to analyze jet induced mixing in cryogenic propellant tankage is presented along with representative results. Similar information is presented for a recent examination of on-orbit self-pressurization. A study of propellant reorientation has recently been initiated and preliminary results are included. The presentation concludes with a list of ongoing efforts and projected goals. Author

N87-21149*# Boeing Aerospace Co., Kent, Wash.
MIXING-INDUCED FLUID DESTRATIFICATION AND ULLAGE CONDENSATION
JERE S. MESEROLE, OGDEN S. JONES, and ANTHONY F. FORTINI (Anthony Enterprises, Federal Way, Wash.) *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 101-117 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

In many applications, on-orbit storage and transfer of cryogens will require forced mixing to control tank pressure without direct venting to space. During a no-vent transfer or during operation of a thermodynamic vent system in a cryogen storage tank, pressure control is achieved by circulating cool liquid to the liquid-vapor interface to condense some of the ullage vapor. To measure the pressure and temperature response rates in mixing-induced condensation, an experiment has been developed using Freon 11 to simulate the two-phase behavior of a cryogen. A thin layer at the liquid surface is heated to raise the tank pressure, and then a jet mixer is turned on to circulate the liquid, cool the surface, and reduce the pressure. Many nozzle configurations and flow rates are used. Tank pressure and the temperature profiles in the ullage and the liquid are measured. Initial data from this ground test are shown correlated with normal-gravity and drop-tower dye-mixing data. Pressure collapse times are comparable to the dye-mixing times, whereas the times needed for complete thermal mixing are much longer than the dye-mixing times. Author

N87-21150*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRYOGENIC FLUID MANAGEMENT FLIGHT EXPERIMENT (CFMFE)
DAVID M. DEFELICE *In its* Microgravity Fluid Management Symposium p 119-124 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

Since its foundation, NASA has excelled in the study and development of microgravity fluid management technology. With the advent of space-based vehicles and systems, the use of and the ability to efficiently manage subcritical cryogens in the space environment has become necessary to our growing space program. The NASA Lewis Research Center is responsible for the planning and execution of a program which will provide advanced in-space cryogenic fluid management technology. A number of future space missions have been identified that will require or could benefit from this technology. These technology needs have been prioritized and the Cryogenic Fluid Management Flight Experiment (CFMFE) is being designed to provide the experimental data necessary for the technological development effort. Author

N87-21151*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SUPERFLUID HELIUM ON ORBIT TRANSFER (SHOOT)
MICHAEL J. DIPIRRO *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 125-138 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

A number of space flight experiments and entire facilities require superfluid helium as a coolant. Among these are the Space Infrared Telescope Facility (SIRTF), the Large Deployable Reflector (LDR), the Advanced X-ray Astrophysics Facility (AXAF), the Particle Astrophysics Magnet Facility (PAMF or Astromag), and perhaps even a future Hubble Space Telescope (HST) instrument. Because these systems are required to have long operational lifetimes, a means to replenish the liquid helium, which is exhausted in the cooling process, is required. The most efficient method of replenishment is to refill the helium dewars on orbit with superfluid helium (liquid helium below 2.17 Kelvin). To develop and prove the technology required for this liquid helium refill, a program of ground and flight testing was begun. The flight demonstration is baselined as a two flight program. The first, described in this paper, will prove the concepts involved at both the component and system level. The second flight will demonstrate active astronaut involvement and semi-automated operation. The current target date for the first launch is early 1991.

N87-21152*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MICROGRAVITY FLUID MANAGEMENT IN TWO-PHASE THERMAL SYSTEMS
RICHARD C. PARISH *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 139-149 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

Initial studies have indicated that in comparison to an all liquid single phase system, a two-phase liquid/vapor thermal control system requires significantly lower pumping power, demonstrates more isothermal control characteristics, and allows greater operational flexibility in heat load placement. As a function of JSC's Work Package responsibility for thermal management of space station equipment external to the pressurized modules, prototype development programs were initiated on the Two-Phase Thermal Bus System (TBS) and the Space Erectable Radiator System (SERS). JSC currently has several programs underway to enhance the understanding of two-phase fluid flow characteristics. The objective of one of these programs (sponsored by the Microgravity Science and Applications Division at NASA Headquarters) is to design, fabricate, and fly a two-phase flow regime mapping experiment in the Shuttle vehicle mid-deck. Another program, sponsored by OAST, involves the testing of a two-phase thermal transoprt loop aboard the KC-135 reduced gravity aircraft to identify system implications of pressure drop variation as a function of the flow quality and flow regime present in a representative thermal system. Author

N87-21156*# Martin Marietta Corp., Denver, Colo.
SHUTTLE MIDDECK FLUID TRANSFER EXPERIMENT: LESSONS LEARNED
JAMES TEGART *In* NASA. Lewis Research Center Microgravity Fluid Management Symposium p 217-224 Apr. 1987
Avail: NTIS HC A10/MF A01 CSCL 22A

This presentation is based on the experience gained from having integrated and flown a shuttle middeck experiment. The experiment, which demonstrated filling, expulsion, and fluid behavior of a liquid storage system under low-gravity conditions, is briefly described. The advantages and disadvantages of middeck payloads compared to other shuttle payload provisions are discussed. A general approach to the integration process is described. The requirements for the shuttle interfaces--such as structures, pressurized systems, materials, instrumentation, and electrical power--are defined and the approach that was used to satisfy these requirements is presented. Currently the middeck experiment is being used as a test bed for the development of various space fluid system components. Author

N87-22001*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE STATION ELECTRIC POWER SYSTEM REQUIREMENTS AND DESIGN

FRED TEREN 1987 15 p Proposed for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa., 10-14 Aug. 1987; sponsored by AIAA, ANS, ASME, SAE, IEEE, ACS and AIChE
(NASA-TM-89889; E-3577; NAS 1.15:89889; AIAA-87-9003)
Avail: NTIS HC A02/MF A01 CSCL 22B

An overview of the conceptual definition and design of the space station Electric Power System (EPS) is given. Responsibilities for the design and development of the EPS are defined. The EPS requirements are listed and discussed, including average and peak power requirements, contingency requirements, and fault tolerance. The most significant Phase B trade study results are summarized, and the design selections and rationale are given. Finally, the power management and distribution system architecture is presented. Author

N87-22003*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COAXIAL TUBE ARRAY SPACE TRANSMISSION LINE CHARACTERIZATION

COLLEEN A. SWITZER and DAVID J. BENTS 1987 12 p Proposed for presentation at the 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, Pa., 10-14 Aug. 1987; sponsored by AIAA, ANS, ASME, SAE, IEEE, ACS and AIChE
(NASA-TM-89864; E-3531; NAS 1.15:89864) Avail: NTIS HC A02/MF A01 CSCL 09C

The coaxial tube array tether/transmission line used to connect an SP-100 nuclear power system to the space station was characterized over the range of reactor-to-platform separation distances of 1 to 10 km. Characterization was done with respect to array performance, physical dimensions and masses. Using a fixed design procedure, a family of designs was generated for the same power level (300 kWe), power loss (1.5 percent), and meteoroid survival probability (99.5 percent over 10 yr). To differentiate between vacuum insulated and gas insulated lines, two different maximum values of the E field were considered: 20 kV/cm (appropriate to vacuum insulation) and 50 kV/cm (compressed SF6). Core conductor, tube, bumper, standoff, spacer and bumper support dimensions, and masses were also calculated. The results of the characterization show mainly how transmission line size and mass scale with reactor-to-platform separation distance. Author

N87-22237*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A 2000-HOUR CYCLIC ENDURANCE TEST OF A LABORATORY MODEL MULTIPROPELLANT RESISTOJET

W. EARL MORREN and JAMES S. SOVEY 1987 24 p Presented at the 19th International Electric Propulsion Conference, Colorado Springs, Colo., 11-13 May 1987; sponsored by AIAA, DGLR and JSASS
(NASA-TM-89854; E-3521; NAS 1.15:89854; AIAA-87-0993)
Avail: NTIS HC A02/MF A01 CSCL 13I

The technological readiness of a long-life multipropellant resistojet for space station auxiliary propulsion is demonstrated. A laboratory model resistojet made from grain-stabilized platinum served as a test bed to evaluate the design characteristics, fabrication methods, and operating strategies for an engineering model multipropellant resistojet developed under contract by the Rocketdyne Division of Rockwell International and Technion Incorporated. The laboratory model thruster was subjected to a 2000-hr, 2400-thermal-cycle endurance test using carbon dioxide propellant. Maximum thruster temperatures were approximately 1400 C. The post-test analyses of the laboratory model thruster included an investigation of component microstructures. Significant observations from the laboratory model thruster are discussed as they relate to the design of the engineering model thruster. Author

N87-22949*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMODYNAMIC ANALYSIS AND SUBSCALE MODELING OF SPACE-BASED ORBIT TRANSFER VEHICLE CRYOGENIC PROPELLANT RESUPPLY

DAVID M. DEFELICE and JOHN C. AYDELOTT Jul. 1987 21 p Prepared for presentation at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987; cosponsored by AIAA, SAE, ASME, and ASEE
(NASA-TM-89921; E-3617; NAS 1.15:89921; AIAA-87-1764)
Avail: NTIS HC A02/MF A01 CSCL 20D

The resupply of the cryogenic propellants is an enabling technology for spacebased orbit transfer vehicles. As part of the NASA Lewis ongoing efforts in microgravity fluid management, thermodynamic analysis and subscale modeling techniques were developed to support an on-orbit test bed for cryogenic fluid management technologies. Analytical results have shown that subscale experimental modeling of liquid resupply can be used to validate analytical models when the appropriate target temperature is selected to relate the model to its prototype system. Further analyses were used to develop a thermodynamic model of the tank chilldown process which is required prior to the no-vent fill operation. These efforts were incorporated into two FORTRAN programs which were used to present preliminary analyticl results. Author

N87-23821*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY PERFORMANCE CHARACTERIZATIONS OF AN ENGINEERING MODEL MULTIPROPELLANT RESISTOJET FOR SPACE STATION APPLICATION

W. EARL MORREN, STUART S. HAY (Purdue Univ., West Lafayette, Ind.), THOMAS W. HAAG, and JAMES S. SOVEY Jul. 1987 24 p Presented at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987; cosponsored by AIAA, SAE, ASME, and ASEE
(NASA-TM-100113; E-3657; NAS 1.15:100113; AIAA-87-2120)
Avail: NTIS HC A02/MF A01 CSCL 20H

Presented are the results of a program to describe the operational characteristics of an engineering model multipropellant resistojet for application as an auxiliary propulsion system for the space station. Performance was measured on hydrogen, helium, methane, water (steam), nitrogen, air, argon, and carbon dioxide. Thrust levels ranged form 109 to 355 mN, power levels ranged from 167 to 506 W, and specific impulse values ranged from 93 to 385 sec, depending on the propellant, chamber pressure, and heater current level selected. Detailed thermal maps of the heater and heat exchanger were also obtained for operation with carbon dioxide. Author

N87-24536*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RESISTOJET PLUME AND INDUCED ENVIRONMENT ANALYSIS M.S. Thesis - Case Western Reserve Univ.

DAVID J. HOFFMAN May 1987 60 p
(NASA-TM-88957; E-3410; NAS 1.15:88957) Avail: NTIS HC A04/MF A01 CSCL 21H

The source flow method developed by G.A. Simons for calculating the far field plume density produced by high thrust rocket nozzles is modified and applied to low thrust resistojet nozzles with Reynolds numbers on the order of 4000 to 7000. Simons' original method and the modified analysis are compared to mass flux measurements taken by Chirivella in a JPL vacuum tank facility. Results of the comparison show the modified analysis presented more accurately predicts the mass flux at large angles from the nozzle centerline than Simons' original method. The modified Simons analysis is then used to calculate the plume structure and two contamination parameters, number column density and back flow, for five nozzle geometries representative of Space Station resistojets. Author

N87-24641*# Beech Aircraft Corp., Boulder, Colo.
SPACE STATION EXPERIMENT DEFINITION: LONG-TERM CRYOGENIC FLUID STORAGE Final Report
R. L. JETLEY and R. D. SCARLOTTI Washington NASA Jun. 1987 257 p
(Contract NAS3-24661)
(NASA-CR-4072; E-3463; NAS 1.26:4072; BAC-ER-18056-8)
Avail: NTIS HC A12/MF A01 CSCL 20D

The conceptual design of a space station Technology Development Mission (TDM) experiment to demonstrate and evaluate cryogenic fluid storage and transfer technologies is presented. The experiment will be deployed on the initial operational capability (IOC) space station for a four-year duration. It is modular in design, consisting of three phases to test the following technologies: passive thermal technologies (phase 1), fluid transfer (phase 2), and active refrigeration (phase 3). Use of existing hardware was a primary consideration throughout the design effort. A conceptual design of the experiment was completed, including configuration sketches, system schematics, equipment specifications, and space station resources and interface requirements. These requirements were entered into the NASA Space Station Mission Data Base. A program plan was developed defining a twelve-year development and flight plan. Program cost estimates are given. Author

N87-25422*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION PROPULSION SYSTEM TECHNOLOGY
ROBERT E. JONES, PHILLIP R. MENG, STEVEN J. SCHNEIDER, JAMES S. SOVEY, and ROBERT R. TACINA 1987 18 p
Proposed for presentation at the 38th International Astronautical Federation Congress, Brighton, England, 10-17 Oct. 1987
(NASA-TM-100108; E-3648; NAS 1.15:100108) Avail: NTIS HC A02/MF A01 CSCL 21H

Two propulsion systems have been selected for the space station: O/H rockets for high thrust applications and the multipropellant resistojets for low thrust needs. These thruster systems integrate very well with the fluid systems on the station. Both thrusters will utilize waste fluids as their source of propellant. The O/H rocket will be fueled by electrolyzed water and the resistojets will use stored waste gases from the environmental control system and the various laboratories. This paper presents the results of experimental efforts with O/H and resistojet thrusters to determine their performance and life capability. Author

N87-25888*# New Mexico Univ., Albuquerque. Dept. of Chemical and Nuclear Engineering.
AN ANALYSIS OF BIPROPELLANT NEUTRALIZATION FOR SPACECRAFT REFUELING OPERATIONS
DAVID KAUFFMAN *In* NASA. Lyndon B. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1986, Volume 2 14 p Jun. 1987
Avail: NTIS HC A13/MF A01 CSCL 21H

Refueling of satellites on orbit with storable propellants will involve venting part or all of the pressurant gas from the propellant tanks. This gas will be saturated with propellant vapor, and it may also have significant amounts of entrained fine droplets of propellant. The two most commonly used bipropellants, monomethyl hydrazine (MMH) and nitrogen tetroxide (N2O4), are highly reactive and toxic. Various possible ways of neutralizing the vented propellants are examined. The amount of propellant vented in a typical refueling operation is shown to be in the range of 0.2 to 5% of the tank capacity. Four potential neutralization schemes are examined: chemical decomposition, chemical reaction, condensation and adsorption. Chemical decomposition to essentially inert materials is thermodynamically feasible for both MMH and N2O4. It would be the simplest and easiest neutralization method to implement. Chemical decomposition would require more complex control. Condensation would require a refrigeration system and a very efficent phase separator. Adsorption is likely to be much heavier. A preliminary assessment of the four neutralization shemes is presented, along with suggested research and development plans. Author

N87-26058# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
A STUDY OF FLUID TRANSFER MANAGEMENT IN SPACE Executive Summary Report
J. KOWALEK, J. POELSTRA, G. BERGER, and E. ROMERO Paris, France ESA Feb. 1986 76 p
(Contract ESTEC-6013/84-NL-PB(SC))
(FTMS-RPT-006; ESA-CR(P)-2348; ETN-87-99995) Avail: NTIS HC A05/MF A01

In-orbit refueling was studied. Direct fluid transfer is feasible to refuel storable propulsion fluids in orbit. Automated refueling takes place in conjunction with a berthing port. Fluid interfaces using hose connections are also possible for dedicated applications. The propellant masses to be transferred range from 100 to 1000 kg. The cost effectiveness of a refueling system increases significantly if the tank capacity is designed for multiple refueling operation. A refueling system has an autonomous control capability for the refueling procedure with supervision possibility by the supplier spacecraft or by remote control. For refueling, the receiver propulsion system is switched off. Nevertheless, the receiver propulsion system has to ensure functional access for control of components and for monitoring of data which are required for the execution of the refueling procedure. Therefore, a receiver propulsion system contains elements needed for refueling only. ESA

N87-26062*# General Electric Co., Philadelphia, Pa. Re-Entry Systems Operations.
SYSTEM TECHNOLOGY ANALYSIS OF AEROASSISTED ORBITAL TRANSFER VEHICLES. MODERATE LIFT/DRAG (0.75-1.5). VOLUME 1A, PART 1: EXECUTIVE SUMMARY, PHASE 1 Final Report
Aug. 1985 30 p
(Contract NAS8-35096)
(NASA-CR-179139; NAS 1.26:179139; REPT-85SDS2184-VOL-1A-PT-1) Avail: NTIS HC A03/MF A01 CSCL 22A

Activities and significant results of Phase 1 of a study to access aeroassisted orbit transfer vehicle (AOTV) system technology are summarized. Broad concept evaluations were performed and the technology requirements and sensitivities for ground based AOTV's over a range of vehicle hypersonic lift/drag (L/D) from 0.75 to 1.5 were systematically identified and assessed. The four major task areas included systems analysis, system/subsystem trades, technology payoff assessment and plan, and cost analysis. Findings indicate that substantial performance improvements and hence cost benefit can be obtained by developing enhanced technologies such as: (1) low thrust advanced expander LOX-hydrogen engines with specific impulse of 480 to 490 sec; (2) reducing the external thermal protection system weight and increasing the maximum allowable bond/structure temperature; and (3) reducing the structural shell weight by improving the quality of the design allowable data, or use of advanced structural materials. Results also show that use of mid L/D AOTV's provide significant aerodynamic plane change capability and control authority over trajectory dispersions and off-nominal atmospheres. M.G.

N87-26081*# General Dynamics Corp., San Diego, Calif. Space Systems Div.
DESIGN AND DEMONSTRATE THE PERFORMANCE OF CRYOGENIC COMPONENTS REPRESENTATIVE OF SPACE VEHICLES: START BASKET LIQUID ACQUISITION DEVICE PERFORMANCE ANALYSIS
Feb. 1987 50 p

(Contract NAS8-31778)
(NASA-CR-179138; NAS 1.26:179138; GDSS-CRAD-87-004)
Avail: NTIS HC A03/MF A01 CSCL 22B

The objective was to design, fabricate and test an integrated cryogenic test article incorporating both fluid and thermal propellant management subsystems. A 2.2 m (87 in) diameter aluminum test tank was outfitted with multilayer insulation, helium purge system, low-conductive tank supports, thermodynamic vent system, liquid acquisition device and immersed outflow pump. Tests and analysis performed on the start basket liquid acquisition device and studies of the liquid retention characteristics of fine mesh screens are discussed. Author

N87-26116*# Aerojet Strategic Propulsion Co., Sacramento, Calif.

EVALUATION OF CARBON-CARBON FOR SPACE ENGINE NOZZLE

J. P. SUHOZA, J. L. KIRKHART, J. O. BIRD, G. W. CAWOOD, and R. L. BICKFORD (Aerojet TechSystems Co., Sacramento, Calif.) *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 379-385 Aug. 1986
(Contract NAS8-35971)
Avail: NTIS HC A25/MF A01 CSCL 11D

An investigation is underway to determine the suitability of carbon-carbon composite materials for lightweight nozzle extensions on the Orbit Transfer Vehicle (OTV). The best combinations of fiber precursor, matrix material, and oxidation protection coatings are being evaluated in a series of hot-fire tests in an O sub 2/H sub 2 rocket nozzle environment. Evaluation criteria include life expectancy (recession), strength to weight, producibility, maturity, and cost. A data base of carbon-carbon performance in the OTV nozzle environment will be established which may be used in designing a full-scale OTV nozzle extension. Author

N87-26129*# Martin Marietta Aerospace, Denver, Colo.

PROPULSION RECOMMENDATIONS FOR SPACE STATION FREE FLYING PLATFORMS

L. R. REDD and L. J. ROSE *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 515-523 Aug. 1986
(Contract NAS3-23893)
Avail: NTIS HC A25/MF A01 CSCL 21H

Propulsion system candidates have been defined for Space Station free flying platforms for the purpose of comparison and to understand the impact of the various mission requirements on the candidate designs. Recommendations for propulsion for each of the various platforms are given. Author

N87-26130# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.

HYDROGEN/OXYGEN ECONOMY FOR THE SPACE STATION

JOSEPH E. GRAETCH *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 525-532 Aug. 1986
Avail: NTIS HC A25/MF A01 CSCL 22B

The concept of a hydrogen/oxygen economy, which involves the functional integration of the major water/hydrogen/oxygen producers and consumers aboard the Space Station is discussed. It is shown that all or most of the projected propellant needs of the Station can be met with propellants derived from the hydrogen/oxygen economy, while meeting all other water and oxygen needs of the Station. An alternative is suggested to the baseline Station air revitalization program in which the Sabatier process is used in place of the Bosch process. It is shown that the Sabatier process has about the same capability to meet the propulsion needs, while offering a number of design and operational options that may impact both the environmental control and life support system and the propulsion system. Author

N87-26131*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SPACE STATION PROPULSION TEST BED: A COMPLETE SYSTEM

G. L. BRILEY, A. M. NORMAN (Rockwell International Corp., Canoga Park, Calif.), L. JONES, and H. CAMPBELL *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 533-538 Aug. 1986 Previously announced in IAA as A86-42615
Avail: NTIS HC A25/MF A01 CSCL 14B

A test bed was fabricated to demonstrate hydrogen/oxygen propulsion technology readiness for the Initial Operating Capabilities (IOC) space station application and for use as a means to test evolving technology for the growth station. The test bed, its function, and plans for future testing are discussed. Author

N87-26132*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A 25-LBF GASEOUS OXYGEN/GASEOUS HYDROGEN THRUSTER FOR SPACE STATION APPLICATION

B. J. HECKERT, T. I. YU (Rockwell International Corp., Canoga Park, Calif.), S. L. ALLUMS, and E. A. CARRASQUILLO *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 539-546 Aug. 1986
Avail: NTIS HC A25/MF A01 CSCL 21H

A prototype 25 lb sub f gaseous oxygen/gaseous hydrogen thruster for Space Station propulsion application was designed and fabricated by Rocketdyne and endurance tested at the NASA/Marshall space Flight Center. The thruster incorporates a regeneratively cooled thrust chamber with a nozzle exit area ratio of 30, a 12-element coaxial injector, a spark igniter, and close-coupled propellant valves. Test results indicate that all major technology issues for long-life gaseous oxygen/gaseous hydrogen thrusters for Space Station application have been resolved.
Author

N87-26133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROVEN, LONG-LIFE HYDROGEN/OXYGEN THRUST CHAMBERS FOR SPACE STATION PROPULSION

G. PAUL RICHTER and HAROLD G. PRICE *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 547-564 Aug. 1986 Previously announced as N86-32522
Avail: NTIS HC A25/MF A01 CSCL 21H

A 25 lb sub f hydrogen/oxygen thruster has been developed and proven as a viable candidate to meet the needs of the Space Station Program. Likewise, a 50 lb sub f hydrogen/oxygen thrust chamber has been developed and has demonstrated reliable, long-life expectancy at anticipated Space Station operating conditions. Both these thrust chambers were based on design criteria developed in previous thruster programs. Extensive thermal analysis and models were used to design the thrusters to achieve total impulse goals of 2 million lb sub f sec. Test data from each thruster are compared to the analytical predictions for the performance and heat transfer characteristics. Also, the results of thrust chamber life verification tests are presented. Author

N87-26135*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WATER-PROPELLANT RESISTOJETS FOR MAN-TENDED PLATFORMS

ALLEN J. LOUVIERE (Space Industries, Inc., Webster, Tex.), ROBERT E. JONES, W. EARL MORREN, and JAMES S. SOVEY 1987 17 p Proposed for presentation at the 38th International Astronautical Federation Congress, Brighton, England, 10-17 Oct. 1987
(NASA-TM-100110; E-3649; NAS 1.15:100110; IAF-87-259)
Avail: NTIS HC A02/MF A01 CSCL 21H

The selection of a propulsion system for a man-tended platform has been influenced by the planned use of resistojets for drag make-up on the manned space station. For that application a resistojet has been designed that is capable of operation with a wide variety of propellants, including water. The reasons for the selection of water as the propellant and the performance of water as a propellant are discussed. The man-tended platform and its mission requirements are described. Author

N87-28405# Brookhaven National Lab., Upton, N. Y.
NUCLEAR PROPULSION SYSTEMS FOR ORBIT TRANSFER BASED ON THE PARTICLE BED REACTOR
J. R. POWELL, H. LUDEWIG, F. L. HORN, K. ARAJ, R. BENENATI, O. LAZARETH, G. SLOVIK, M. SOLON, W. TAPPE, J. BELISLE (Grumman Aerospace Corp., Bethpage, N.Y.) et al. 1987 30 p Presented at the 4th Symposium on Space Nuclear Power Systems, Albuquerque, N. Mex., 12 Jan. 1987 Prepared in cooperation with Babcock and Wilcox Co., Lynchburg, Va. and Garrett Engine Co., Phoenix, Ariz.
(Contract DE-AC02-76CH-00016)
(DE87-010060; BNL-39695; CONF-870102-23) Avail: NTIS HC A03/MF A01

The technology of nuclear direct propulsion orbit transfer systems based on the Particle Bed Reactor (PBR) is described. A 200 megawatt illustrative design is presented fur LEO to GEO and other high V missions. The PBR-NOTV can be used in a one-way mode with the shuttle or an expendable launch vehicle, e.g., the Titan 34D7, or as a two-way reusable space tug. In the one-way mode, payload capacity is almost three times greater than that of chemical OTV's. PBR technology status is described and development needs outlined. DOE

N87-29930*# International Fuel Cells Corp., South Windsor, Conn.
ADVANCED FUEL CELL CONCEPTS FOR FUTURE NASA MISSIONS Abstract Only
J. K. STEDMAN *In* NASA-Lewis Research Center, Space Electrochemical Research and Technology (SERT) p 125 Sep. 1987
Avail: NTIS HC A16/MF A01 CSCL 10C

Studies of primary fuel cells for advanced all electric shuttle type vehicles show an all fuel cell power system with peak power capability of 100's of kW to be potentially lighter and have lower life cycle costs than a hybrid system using advanced H2O2 APU's for peak power and fuel cells for low power on orbit. Fuel cell specific weights of 1 to 3 lb/kW, a factor of 10 improvement over the orbiter power plant, are projected for the early 1990's. For satellite applications, a study to identify high performance regenerative hydrogen oxygen fuel cell concepts for geosynchronous orbit was completed. Emphasis was placed on concepts with the potential for high energy density (Wh/lb) and passive means for water and heat management to maximize system reliability. Both alkaline electrolyte and polymer membrane fuel cells were considered. Author

10

MECHANISMS, AUTOMATION, AND ARTIFICIAL INTELLIGENCE

Includes descriptions of simulations, models, analytical techniques, and requirements for remote, automated and robotic mechanical systems.

A87-31493
USE OF HEADS-UP DISPLAYS, SPEECH RECOGNITION, AND SPEECH SYNTHESIS IN CONTROLLING A REMOTELY PILOTED SPACE VEHICLE
CRAIG S. HARTLEY and ROBERT PULLIAM (Martin Marietta Space Operations Simulator Laboratory, Denver, CO) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 338-345.

Displays and controls must be optimized for the future operation of remotely piloted space vehicles (RPSVs). Experiments at the Martin Marietta Space Operations Simulator Laboratory in Denver are reported in which heads-up displays and voice input/output were implemented on an experimental pilot console. These displays and controls were developed interactively during the simulation of RPSV and Space Station operations. Demonstrated and evaluated were 7 heads-up reticle displays, 2 heads-up data displays, selection of displays by voice command, use of voice command to call for range and rate data, and the voice annunciation of alarms. Development continues and will explore application of expert systems to RPSV control. Author

A87-32449
CONTROL OF A FLEXIBLE SPACE MANIPULATOR
TOSHIO FUKUDA (Tokyo University of Science, Japan) and ATSUSHI ARAKAWA IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1285-1290. refs

A flexible control method based on the dynamic characteristics of flexible manipulator arms is proposed. The modeling of the dynamic characteristics of flexible arms with two degrees-of-freedom is described; the modeling takes into consideration the coupling between the arms due to vibrations. The ability of the basic characteristics of the flexible robotic arms to control the arms is evaluated experimentally, and it is determined that the control method is effective. I.F.

A87-32633
A SIMULATION CAPABILITY FOR FUTURE SPACE FLIGHT
RICHARD A. SKIDMORE and ROBERT PULLIAM (Martin Marietta Corp., Denver, CO) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 8 p.
(SAE PAPER 861784)

The limited number of laboratories which can simulate operations in space provide a critical engineering resource. Among these the Martin Marietta Space Operations Simulator Laboratory in Denver provides resources for real-time piloted flight and other human/machine simulations. Its facilities include a 6 degree-of-freedom (DOF), man-rated carriage with a 3 DOF target gimbal, which is computer driven to simulate flight in space. This system can simulate astronaut freeflight, or the relative motion of any two bodies in space. Other resouces include a manipulator arm, a neutral bouyancy tank, a Shuttle Orbiter aft flight deck mockup, and a large screenflight simulator. Recently developed is computer generated imagery for low cost space simulation, with 3-body motion, flexible body dynamics, and simulated handling of payloads at the Space Station. Advanced pilot consoles are used to control simulations and for control-display experiments. New resources are being developed. Author

A87-32745* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
LASER DOCKING SYSTEM FLIGHT EXPERIMENT
HARRY O. ERWIN (NASA, Johnson Space Center, Houston, TX) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 335-342.
(AAS PAPER 86-043)

Experiments necessary in the development of the Laser Docking System (LDS) are described. The LDS would be mounted in the Orbiter payload bay, along with a grid connected by fiber optic link to a computer in the cabin. The tests would be performed to aid in the design of an operational sensor which could track a passive target accurately enough to permit soft docking. Additional data would be gained regarding the LDS performance in space, the effects of Orbiter RCS plume impingement on the target, and refinements needed for the flight hardware. A working model which includes an IR laser steered by galvanometer-driven motors for bouncing beams off retroreflectors mounted on targets is described, together with a 300 ft long indoor test facility. Tests on Orbiter flights would first be in a wholly automatic mode and then in a man-in-the-loop mode. M.S.K.

A87-32746* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEM ARCHITECTURE FOR THE TELEROBOTIC WORK SYSTEM

LYLE M. JENKINS (NASA, Johnson Space Center, Houston, TX) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 343-348.
(AAS PAPER 86-044)

The functional and performance requirements and design concepts for a telerobotic work system (TWS) being considered as an adjunct to the Shuttle Remote Manipulator System and other applications are described. The multiple-armed free-flyer would be controlled by an operator in the Orbiter cabin and would perform remote sensing and manipulative tasks that EVA crew otherwise carry out. The TWS could also perform hazardous tasks, construction operations, and be an asset to the Space Station. Alternative system architectures are described, including the man-machine interface, the types of manipulators and their stowage, and the controls and backup systems. Potential terrestrial applications of the TWS concept, augmented with AI capabilities, are discussed. M.S.K.

A87-33867*# National Aeronautics and Space Administration, Washington, D.C.
OVERVIEW OF THE NASA AUTOMATION AND ROBOTICS RESEARCH PROGRAM
LEE HOLCOMB and RON LARSEN (NASA, Washington, DC) IN: Association for Unmanned Vehicle Systems; Annual Meeting, 12th, Anaheim, CA, July 15-17, 1985, Preliminary Proceedings . Washington, DC, Association for Unmanned Vehicle Systems, 1985, 20 p. refs

NASA studies over the last eight years have identified five opportunities for the application of automation and robotics technology: (1) satellite servicing; (2) system monitoring, control, sequencing and diagnosis; (3) space manufacturing; (4) space structure assembly; and (5) planetary rovers. The development of these opportunities entails two technology R&D thrusts: telerobotics and system autonomy; both encompass such concerns as operator interface, task planning and reasoning, control execution, sensing, and systems integration. O.C.

A87-37300*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MANNED SPACECRAFT AUTOMATION AND ROBOTICS
JON D. ERICKSON (NASA, Johnson Space Center, Houston, TX) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 417-426. refs

The Space Station holds promise of being a showcase user and driver of advanced automation and robotics technology. The author addresses the advances in automation and robotics from the Space Shuttle - with its high-reliability redundancy management and fault tolerance design and its remote manipulator system - to the projected knowledge-based systems for monitoring, control, fault diagnosis, planning, and scheduling, and the telerobotic systems of the future Space Station. Author

A87-40844#
ROBOTS ON THE SPACE STATION
ERIC J. LERNER Aerospace America (ISSN 0740-722X), vol. 25, June 1987, p. 42-45.

Teleoperated robotic devices, or 'telerobots', such as those in use at nuclear processing facilities, are undergoing Space Station applicability evaluations which give attention to such questions as the degree of autonomy feasible or desirable for such devices and their most advantageous location. The mechanical elements of the telerobot are noted to require the most intensive modification for operations in a microgravity environment, due to the presence of backlash in many of its operations. A torque feedback loop has been developed which directly controls the force borne by arm joints. O.C.

A87-41152#
AN INTEGRATED APPROACH TO SPACECRAFT DESIGN FOR ROBOTIC SERVICING
J. L. NEVINS, D. E. WHITNEY, and R. W. METZINGER (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 9 p. refs
(AIAA PAPER 87-1672)

A highly integrated approach to spacecraft design (the strategic approach to product design) is developed which involves all aspects of the manufacturing process as well as product design and its eventual use. This approach is important in the context of the technology (EVA or telerobotics) currently available to support on-orbit assembly or servicing. The forces driving this approach for industry include the complexity of new products and the disappearance of manual assembly as an option; for spacecraft, they include the need for exceptionally long product life and for spacecraft designs that can be maintained rather than replaced. K.K.

A87-41153#
THE CANADIAN ROBOTIC SYSTEM FOR THE SPACE STATION
DOUGLAS CASWELL (National Research Council of Canada, Ottawa) and DEV GOSSAIN (Spar Aerospace, Ltd., Remote Manipulator Systems Div., Toronto, Canada) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 6 p.
(AIAA PAPER 87-1677)

The general concept of the Mobile Servicing Center and the Special Purpose Dextrous Manipulator (SPDM), both of which are parts of the Space Station Mobile Servicing System, is described. The role of the SPDM in the assembly and maintenance of the Station and the servicing of payloads and other equipment is outlined. Planning activities for technology diffusion and exploitation of the terrestrial economy are also addressed. C.D.

A87-45797* Catholic Univ. of America, Washington, D.C.
CONTROL OF ROBOT MANIPULATOR COMPLIANCE
CHARLES C. NGUYEN, FARHAD J. POORAN (Catholic University of America, Washington, DC), and TIMOTHY PREMACK (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Recent trends in robotics: Modeling, control and education. Amsterdam, North-Holland, 1986, p. 237-242. refs
(Contract NAG5-780)

Robotic assembly operations such as mating and fastening of parts are more successful if the robot manipulator compliance can be controlled so that various coordinates are free to comply with external constraints. This paper presents the design of a hybrid controller to provide active compliance to a six-degree-of-freedom robot built at NASA/GSFC using force and position feedback. Simulation results of a 2 degree-of-freedom model is presented and discussed. Author

A87-46704#
ROBOTIC TELEPRESENCE
GEORGE C. MOHR (USAF, Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: 1987 Annual Reliability and Maintainability Symposium, Philadelphia, PA, Jan. 27-29, 1987, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 25-30. refs

The concept of robotic telepresence, the linking of human hands and eyes with a robot's hands and eyes to permit viewing and manipulating objects from a remote location, is discussed. A 'master-slave' relationship between the human controller and robot is based on closed loop visual, tactile, and force sensing and display, coupled with head, eye, arm, hand, and finger position control of the robotic system. Technological areas requiring increased emphasis include hand-finger position sensing, tactile-force displays, and time-delay control compensation. The concept has application to the performance of maintenance, repair, and construction tasks in a hostile environment to enhance military capability, and for manned operations in both orbital and deep space environments. R.R.

A87-48156

CONTROL OF AN AUTONOMOUS SPACECRAFT RENDEZVOUS AND DOCKING MANEUVER BY MEANS OF IMAGE PROCESSING [KONTROLLE EINES AUTONOM ABLAUFENDEN ANNAEHERUNGS- UND KOPPLUNGSMANOEVERS IN DER RAUMFAHRT DURCH BILDVERARBEITUNG]

R. HEHNEN (AEG AG, Wedel, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 481-503. In German.
(DGLR PAPER 86-122)

The design concept and predicted performance of a spacecraft rendezvous and docking (RVD) control are discussed and illustrated with drawings and diagrams. The RVD system is based on a video tracking system for ship maneuvers at offshore oil-drilling platforms. The operation of the ship system is described; the demands imposed by the RVD mission are outlined; the hardware design (a CCD video camera with 512 x 512-pixel format and field of view switchable among 500, 133, and 33 mrad; an illuminator; processing and correlation electronics; and reflectors) is presented; and the fundamental principles of the pattern recognition techniques employed are summarized. T.K.

A87-51975#

DEVELOPMENT OF A SMALL-SIZED SPACE MANIPULATOR

YOSHITUGU TODA, KAZUO MACHIDA, TOSHIAKI IWATA, MASAO INOUE, KATSUHIKO YAMADA et al. Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 401, 1987, p. 294-302. In Japanese, with abstract in English. refs

Future space stations and space factories which require many types of manipulators or robots for assembling and servicing in space, especially demand small-sized manipulators for dexterous tasks. A 1-meter class articulated manipulator with space environment durability and light weight has been developed. This paper presents the system design of the manipulator and development efforts of its components. The design of actuators and a hand, a tribological investigation of mechanical elements in the vacuum environment, the multiprocessor control system, and the dynamic control algorithm of the arm, are described. Author

A87-53059#

SPACE STATION AUTONOMY - WHAT ARE THE CHALLENGES? HOW CAN THEY BE MET?

RONALD A. HAMMOND (Boeing Computer Services Advanced Technology Center, Seattle, WA) IN: AAAIC '86 - Aerospace Applications of Artificial Intelligence; Proceedings of the Second Annual Conference, Dayton, OH, Oct. 14-17, 1986. Volume 1 . Dayton, OH, AAAIC Conference Secretariat, 1986, p. 2-6. refs

Autonomous systems encompassing knowledge-based systems and robotics for various tasks will be required to aid both the on-orbit and ground support operations of the NASA Space Station. These autonomous systems will reduce human exposure to hazardous environments as well as training requirements and involvement in repetitive tasks. Advanced automation and robotic systems will require advanced operator/system interfaces. Currently envisioned are knowledge-based systems for on-orbit and for ground operations, and robotics for both on-orbit experimental and manufacturing processes, as well as routine orbital 'housekeeping' operations. O.C.

A87-53061

THE ASTRONAUT AND THE ROBOT - SHORT- AND LONG-TERM SCENARIOS FOR SPACE TECHNOLOGY

ANDRE LEBEAU (Conservatoire National des'Arts et Metiers, Paris, France) (Futuribles, Sept. 1986) Space Policy (ISSN 0265-9646), vol. 3, Aug. 1987, p. 207-220.

The prospects for space technology over the next decades are assessed, contrasting the slowing growth of 'conventional' space activities (communications, remote sensing, or collection of scientific data) with the potential of new-generation manned systems (the Space Station, Mir/Salyut, and Hermes). The short-term military (ABM/SDI) and civilian (materials processing) applications of such systems are considered, but the need for a long-term global strategy aimed at freeing technology from the limitations of the biosphere is stressed. It is suggested that advances in robotics could reduce the number of human interventions required to meet these goals. Increased privatization of mature technologies and intense efforts to mobilize public opinion are recommended. Also included are critical examinations of (1) the current technological and competitive status of U.S. and European launch vehicles and (2) the arguments used by some space scientists against the emphasis on manned programs.
T.K.

N87-20370# National Aeronautical Establishment, Ottawa (Ontario).

USE OF A VIDEO-PHOTOGRAMMETRY SYSTEM FOR THE MEASUREMENT OF THE DYNAMIC RESPONSE OF THE SHUTTLE REMOTE MANIPULATOR ARM

G. L. BASSO and R. B. KULCHYSKI *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 12 p Jul. 1986
Avail: NTIS HC A12/MF A01

A video-photogrammetry system was used to obtain the dynamic response of the Canadian developed, space transportation system remote manipulator arm from video tape recordings of two space based test events - specifically, an auto-trajectory and a backup mode test sequence. The application of this system to this task represented a non-generic use in that no pre-launch preparations were made for implementing this technique. The procedures used to extract the response information from the video tapes are outlined. The stated resolution of the video-photogrammetry system is 1 part in 5000 (1 sigma) - typically, 0.03mm for a 12.5mm image plane size. Within this capability, the amplitude of the response for the auto-trajectory sequence was obtained with an estimated resolution of 1mm with a camera-to-object spacing of 2.18m; and for the backup mode, 3mm at a spacing of 13.78m. In both instances, dynamic parameters such as frequency and damping were readily derived from the response measurements.
Author

N87-20774# Oak Ridge National Lab., Tenn.

THE OAK RIDGE NATIONAL LABORATORY'S ROBOTICS AND INTELLIGENT SYSTEMS PROGRAM

S. A. MEACHAM 23 Jan. 1987 8 p Presented at the Roane-Anderson Economic Council Meeting, Oak Ridge, Tenn., 23 Jan. 1987
(Contract DE-AC05-84OR-21400)
(DE87-004627; CONF-870148-1) Avail: NTIS HC A02/MF A01

The goals of the newly formed Robotics and Intelligent Systems Program are discussed. The application of the remote systems technology developed by the Consolidated Fuel Reprocessing Program for the Department of Energy is presented. The activities (satellite refueling and space station truss assembly) with the National Aeronautics and Space Administration are presented in a videotape format with narration by the presenter. The goals of technology transfer to the private sector and the potential positive impact on the community conclude the oral presentation. DOE

N87-22231# Oak Ridge National Lab., Tenn.

APPLICATION OF A TRACTION-DRIVE 7-DEGREES-OF-FREEDOM TELEROBOT TO SPACE MANIPULATION

D. P. KUBAN and W. R. HAMEL 1987 18 p Presented at the 10th American Astronautical Society Annual Guidance and Control Conference, Keystone, Colo., 31 Jan. 1987
(Contract DE-AC05-84OR-21400)
(DE87-004616; CONF-870147-1) Avail: NTIS HC A02/MF A01

The Space Station Program marks a new era in space exploration and habitation. To meet the challenges of this new era, more extensive use of remote manipulation and robotics is expected. This paper describes a new space telerobot concept which addresses both teleoperations and robotics needs of future space programs, while merging the desirable characteristics of both technologies. This new concept is based on knowledge and experience gained from manipulator systems developed to meet the needs of remote nuclear applications. It merges desirable characteristics of teleoperation and robotic technologies. Presented here are design goals for the telerobot, a description of the mechanical and control abilities, and applications for Earth and space. The concept incorporates mechanical traction drives, redundant kinematics, and modular arm subelements to provide a backlash-free manipulator capable of obstacle avoidance. Further development of this telerobot is in progress at the Oak Ridge National Laboratory. DOE

N87-22233# Oak Ridge National Lab., Tenn.
TRACTION-DRIVE TELEROBOT FOR SPACE MANIPULATION
J. N. HERNDON, W. R. HAMEL, and D. P. KUBAN 20 Feb. 1987 14 p Presented at the IEEE International Conference on Robotics and Automation, Raleigh, N.C., 30 Mar. 1987
(Contract DE-AC05-84OR-21400)
(DE87-005326; CONF-870354-2) Avail: NTIS HC A02/MF A01

The National Aeronautics and Space Administration (NASA) Space Station Program marks the beginning of a new era in space utilization and habitation. Extensive use of remote manipulation and robotics to reduce astronaut extra-vehicular activity is expected. Emphasis on teleoperator technology in early space station phases, followed by growth of autonomous robotics capabilities, is planned. A new telerobot concept has been developed at Oak Ridge National Laboratory (ORNL), under NASA Langley Research Center sponsorship, to address the technical needs of both teleoperations and robotics for these future NASA programs. The concept is based on traction drives, redundant kinematics, modular construction, and a state-of-the-art distributed, hierarchical control system. DOE

N87-22242*# Oak Ridge National Lab., Tenn.
TELEROBOTIC TECHNOLOGY FOR NUCLEAR AND SPACE APPLICATIONS
J. N. HERNDON and W. R. HAMEL Mar. 1987 13 p Presented at the AIAA, NASA and U.S. Air Force Symposium, Arlington, Va., 9 Mar. 1987 Sponsored by NASA
(Contract DE-AC05-84OR-21400)
(NASA-CR-180923; NAS 1.26:180923; DE87-007012; CONF-870395-1) Avail: NTIS HC A02/MF A01 CSCL 13I

Telerobotic development efforts at Oak Ridge National Laboratory are extensive and relatively diverse. Current efforts include development of a prototype space telerobot system for the NASA Langley Research Center and development and large-scale demonstration of nuclear fuel cycle teleoperators in the Consolidated Fuel Reprocessing Program. This paper presents an overview of the efforts in these major programs. DOE

N87-24488# Royal Netherlands Aircraft Factories Fokker, Amsterdam. Attitude Control Dept.
END EFFECTOR DEVELOPMENT STUDY. VOLUME 2: SERVICE END EFFECTOR SUBSYSTEM SPECIFICATION (SEESSPEC) Final Report
AAD VANSWIETEN Paris, France ESA 15 Jul. 1986 42 p
(Contract ESA-1682/84-NL-AN)
(FOK-TR-R-86-091-VOL-2; ESA-CR(P)-2346-VOL-2; ETN-87-99887) Avail: NTIS HC A03/MF A01

An update of the service end effector subsystem specification, based on the experiences obtained during the design iteration of the second phase, is presented. ESA

N87-25336# Royal Netherlands Aircraft Factories Fokker, Amsterdam. Attitude Control Dept.
END EFFECTOR DEVELOPMENT STUDY, VOLUME 1 Final Report
AAD VANSWIETEN Paris, France ESA 15 Jul. 1986 162 p
(Contract ESA-1682/84-NL-AN)
(FOK-TR-R-86-091-VOL-1; ESA-CR(P)-2346-VOL-1; ETN-87-99886) Avail: NTIS HC A08/MF A01

The application of an end-effector mounted on a service manipulator system was investigated, and requirements for the service end-effector subsystem for in-orbit servicing, comprising the end-effector and the associated tools to perform the tasks, were identified. As a result of trade-offs a design was selected, and was developed further resulting in a new design with assembly drawings of the basic end-effector containing the grapple mechanism, the grapple fixture, the integrated service tool, the connector drive unit and the electronic box. The service tools, the definition of the interface between grapple fixture and service tool or orbit replaceable unit, the locking of the service tool in the tool rack for the back-up integrated service tool, and two preliminary designs of service tools, i.e., the multifunctional gripper and the angled wrench, are described. ESA

N87-25337# Royal Netherlands Aircraft Factories Fokker, Amsterdam. Attitude Control Dept.
END EFFECTOR DEVELOPMENT STUDY. VOLUME 3: APPENDICES Final Report
AAD VANSWIETEN Paris, France ESA 15 Jul. 1986 235 p
(Contract ESA-1682/84-NL-AN)
(FOK-TR-R-86-091-VOL-3; ESA-CR(P)-2346-VOL-3; ETN-87-99888) Avail: NTIS HC A11/MF A01

This third of three volumes presents the appendices of the other two volumes. The design rationale of the end effector concept; the multifunctional gripper; the angled wrench; logistic operations; maintenance and repair; assembly; and electrical architecture are discussed. ESA

N87-25583*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
QUICK-DISCONNECT INFLATABLE SEAL ASSEMBLY Patent Application
KURT D. BUEHLER, inventor (to NASA) and JAMES E. FESMIRE, inventor (to NASA) 22 May 1987 20 p
(NASA-CASE-KSC-11368-1; US-PATENT-APPL-SN-052940)
Avail: NTIS HC A02/MF A01 CSCL 11A

The present invention concerns an inflatable seal assembly adapted for use with a bayonet quick-disconnect system particularly useful for the insulated transfer of cryogenic consumables in orbit (such as between a space station and a re-supply vehicle). The zero-leak cryogenic coupling includes a polymeric seal clamped to a male bayonet member with two pairs of tightening rings. The tightening rings threadably engage each other in respective pairs around tapered ends of the inflatable seal member so that a wedging action tightens the seal member about the male bayonet. Once in place, the seal may be inflated via an inflation port so that its expansion provides pressure contact with the inside surface of a coaxial female member. NASA

N87-26355 Rochester Univ., N. Y.
SELF-CALIBRATION STRATEGIES FOR ROBOT MANIPULATORS Ph.D. Thesis
AMITABHA MUKERJEE 1986 114 p
Avail: Univ. Microfilms Order No. DA8706242

One of the requirements of intelligent machines is the ability to adapt to changes in themselves. This ability is called self-calibration to emphasize its autonomous nature. A self-calibration methodology was developed for the class of mechanisms called active articulated chains, which includes robot manipulators, teleoperators and space structures. The two parts of this effort are: (1) estimating the link inertias, and (2) modeling the friction at manipulator joints. Inertia parameters are determined using the equations of motion for each link. These equations are linear in the inertia parameters and the generalized least squares approach was used to solve for them. The inputs are joint reaction forces, obtained through load sensors. Link velocities and accelerations are used to determine the mapping between the joint reactions and the inertia parameters. Singularity parameters are automatically removed from the calibration model. The calibration algorithm does not require the manipulator to execute any particular motion, although the efficiency of calibration will depend on the nature of the movement. Simulation tests were performed to test the robustness of the algorithm against sensor noise. Dissert. Abstr.

N87-26968# Naval Postgraduate School, Monterey, Calif.
COMPUTER SIMULATION OF A ROTATIONAL SINGLE-ELEMENT FLEXIBLE SPACECRAFT BOOM M.S. Thesis
ROBERT S. LAUFENBERG Mar. 1987 91 p
(AD-A181798) Avail: NTIS HC A05/MF A01 CSCL 22B

The requirement to develop a space based remote ocean sensing platform exists within the Department of the Navy. This project models a satellite subsystem with structural flexibility utilizing the Equivalent Rigid Link System (ERLS). Dynamic analysis with computer simulation is presented for a simple flexible boom rotating in three dimensions with and without a point mass at the boom tip. Author (GRA)

N87-27408# Oak Ridge National Lab., Tenn.
REMOTE HANDLING FACILITY AND EQUIPMENT USED FOR SPACE TRUSS ASSEMBLY
T. W. BURGESS 1987 8 p Presented at the Goddard Conference on Space Applications of Artificial Intelligence and Robotics, Greenbelt, Md., 14 May 1987
(Contract DE-AC[illegible]5-84OR-21400)
(DE87-009121; CONF-870591-3) Avail: NTIS HC A02/MF A01

The ACCESS truss remote handling experiments were performed at Oak Ridge National Laboratory's (ORNL's) Remote Operation and Maintenance Demonstration (ROMD) facility. The ROMD facility has been developed by the US Department of Energy's (DOE's) Consolidated Fuel Reprocessing Program to develop and demonstrate remote maintenance techniques for advanced nuclear fuel reprocessing equipment and other programs of national interest. The facility is a large-volume, high-bay area that encloses a complete, technologically advanced remote maintenance system that first began operation in FY 1982. The maintenance system consists of a full complement of teleoperated manipulators, manipulator transport systems, and overhead hoists that provide the capability of performing a large variety of remote handling tasks. ACCESS truss remote assembly was performed in the ROMD facility using the Central Research Laboratory's (CRL) model M-2 servomanipulator. The model M-2 is a dual-arm, bilateral force-reflecting, master/slave servomanipulator which was jointly developed by CRL and ORNL and represents the state of the art in teleoperated manipulators commercially available in the United States today. The model M-2 servomanipulator incorporates a distributed, microprocessor-based digital control system and was the first successful implementation of an entirely digitally controlled servomanipulator. The system has been in operation since FY 1983. DOE

N87-28260# Sener S.A., Madrid (Spain).
SERVICE MANIPULATOR ARM (SMA) FOR A ROBOTIC SERVICING EXPERIMENT (ROSE) Final Report
M. FUENTES, C. COMPOSTIZO, F. DOBLAS, A. MARTINEZ, E. DELAFUENTE, R. GONZALO, J. L. LACOMBE, G. BERGER, and T. BLAIS Paris, France ESA Jun. 1986 106 p
(Contract ESTEC-6174/85-NL-AN(SC))
(ESA-CR(P)-2347; ETN-87-99094) Avail: NTIS HC A06/MF A01

The most important features of the Robotic Servicing Experiment (ROSE), where the servicing equipment such as the Service Manipulator System and the Orbit Replacement Units and the servicing operations are demonstrated in orbit within a representative scenario are identified. The shuttle was selected to carry all the necessary hardware and software into orbit and to provide resources required by the experiments. The in orbit operator will be located in the shuttle cabin or in a pressurized module close to the half pallet where the ROSE elements will be mounted inside the cargo bay. The ROSE and service manipulator arm development programs are outlined. ESA

N87-29009# Societe Europeenne de Propulsion, Vernon (France).
SPOT/MEGS DESIGN AND FLIGHT RESULTS OBTAINED
G. ATLAS and M. SOULIAC (MATRA Espace, Paris-Velizy, France) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 359-364 Nov. 1986
Avail: NTIS HC A21/MF A01

The SPOT MEGS rotation actuator, whose purpose is to ensure that the solar array is always perpendicular to the solar flux, is described. Solar arrays on the SPOT satellites are very flexible, and can be easily excited by the motors that are fitted in the MEGS. To avoid speed stability troubles, a synchronous motor was selected, fed with a compensated current waveform, which leads to a smoother motion of the solar array. Consequently, ultra precise photographs can be taken without stops for repositioning of the satellite. The specifications, performances of MEGS, the stabilization method, and MEGS behavior in orbit are summarized. ESA

N87-29118* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MOBILE REMOTE MANIPULATOR VEHICLE SYSTEM Patent
HAROLD G. BUSH, inventor (to NASA), MARTIN M. MIKULAS, JR., inventor (to NASA), RICHARD E. WALLSOM, inventor (to NASA), and J. KERMIT JENSEN, inventor (to NASA) (Kentron International, Inc., Hampton, Va.) 11 Aug. 1987 17 p Filed 31 Jul. 1985 Supersedes N86-21147 (24 - 11, p 1842)
(NASA-CASE-LAR-13393-1; US-PATENT-4,685,535; US-PATENT-APPL-SN-760799; US-PATENT-CLASS-182-63; US-PATENT-CLASS-182-82; US-PATENT-CLASS-182-223)
Avail: US Patent and Trademark Office CSCL 05H

A mobile remote manipulator system is disclosed for assembly, repair and logistics transport on, around and about a space station square bay truss structure. The vehicle is supported by a square track arrangement supported by guide pins integral with the space station truss structure and located at each truss node. Propulsion is provided by a central push-pull drive mechanism that extends out from the vehicle one full structural bay over the truss and locks drive rods into the guide pins. The draw bar is now retracted and the mobile remote manipulator system is pulled onto the next adjacent structural bay. Thus, translation of the vehicle is inchworm style. The drive bar can be locked onto two guide pins while the extendable draw bar is within the vehicle and then push the vehicle away one bay providing bidirectional push-pull drive. The track switches allow the vehicle to travel in two orthogonal directions over the truss structure which coupled with the bidirectional drive, allow movement in four directions on one plane. The top layer of this trilayered vehicle is a logistics platform. This platform is capable of 369 degees of rotation and will have two astronaut foot restraint platforms and a space crane integral. NASA

N87-29593*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION END EFFECTOR STRATEGY STUDY
STEPHEN J. KATZBERG, ROBERT L. JENSEN, KELLI F. WILLSHIRE, and ROBERT E. SATTERTHWAITE Aug. 1987 91 p
(NASA-TM-100488; NAS 1.15:100488) Avail: NTIS HC A05/MF A01 CSCL 22B

The results of a study are presented for terminology definition, identification of functional requirements, technolgy assessment, and proposed end effector development strategies for the Space Station Program. The study is composed of a survey of available or under-developed end effector technology, identification of requirements from baselined Space Station documents, a comparative assessment of the match between technology and requirements, and recommended strategies for end effector development for the Space Station Program. Author

N87-29658*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THE 21ST AEROSPACE MECHANISMS SYMPOSIUM
May 1987 358 p Symposium held in Houston, Tex., 29 Apr. - 1 May 1987; sponsored by NASA, California Inst. of Tech., and LMSC
(NASA-CP-2470; S-560; NAS 1.55:2470) Avail: NTIS HC A16/MF A01 CSCL 20K

During the symposium technical topics addressed included deployable structures, electromagnetic devices, tribology, actuators, latching devices, positioning mechanisms, robotic manipulators, and automated mechanisms synthesis. A summary of the 20th Aerospace Mechanisms Symposium panel discussions is included as an appendix. However, panel discussions on robotics for space and large space structures which were held are not presented herein.

N87-29865*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
THE DESIGN AND DEVELOPMENT OF A MOBILE TRANSPORTER SYSTEM FOR THE SPACE STATION REMOTE MANIPULATOR SYSTEM
THOMAS W. CARROLL *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 93-101 May 1987
Avail: NTIS HC A16/MF A01 CSCL 05H

The analyses, selection process, and conceptual design of potential candidate Mobile Transporter (MT) systems to move the Space Station Remote Manipulator System (SSRMS) about the exposed faces of the Space Station truss structure are described. The actual requirements for a manipulator system on the space station are discussed, including potential tasks to be performed. The SSRMS operating environment and control methods are analyzed with potential design solutions highlighted. Three general categories of transporter systems are identified and analyzed. Several design solution have emerged that will satisfy these requirements. Their relative merits are discussed, and unique variations in each system are rated for functionality. Author

N87-29866*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TELEROBOTIC WORK SYSTEM: CONCEPT DEVELOPMENT AND EVOLUTION
LYLE M. JENKINS *In its* The 21st Aerospace Mechanisms Symposium p 103-110 May 1987
Avail: NTIS HC A16/MF A01 CSCL 05H

The basic concept of a telerobotic work system (TWS) consists of two dexterous manipulator arms controlled from a remote station. The term telerobotic describes a system that is a combination of teleoperator control and robotic operation. Work represents the function of producing physical changes. System describes the integration of components and subsystems to effectively accomplish the needed mission. Telerobotics reduces exposure to hazards for flight crewmembers and increases their productivity. The requirements for the TWS are derived from both the mission needs and the functional capabilities of existing hardware and software to meet those needs. The development of the TWS is discussed. Author

N87-29867*# Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn.
TRACTION-DRIVE, SEVEN-DEGREE-OF-FREEDOM TELEROBOT ARM: A CONCEPT FOR MANIPULATION IN SPACE
D. P. KUBAN and D. M. WILLIAMS *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 111-130 May 1987
Avail: NTIS HC A16/MF A01 CSCL 05H

As man seeks to expand his dominion into new environments, the demand increases for machines that perform useful functions in remote locations. This new concept for manipulation in space is based on knowledge and experience gained from manipulator systems developed to meet the needs of remote nuclear applications. It merges the best characteristics of teleoperation and robotic technologies. The design goals for the telerobot, a mechanical description, and technology areas that must be addressed for successful implementation are presented and discussed. The concept incorporates mechanical traction drives, redundant kinematics, and modular arm subelements to provide a backlash-free manipulator capable of obstacle avoidance. Author

N87-29868*# Societe Europeenne de Propulsion, Vernon (France).
EXPERIENCES OF CNES AND SEP ON SPACE MECHANISMS ROTATING AT LOW SPEED
G. ATLAS and G. THOMIN (Centre National d'Etudes Spatiales, Toulouse, France) *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 131-144 May 1987
Avail: NTIS HC A16/MF A01 CSCL 13I

Some aspects of knowledge acquired in the field of space mechanisms by Societe Europeenne de Propulsion and Centre National d'Etudes Spatiales in International and French National space programs are described. The experience described centers on the development of these programs: The MEGS (Mechanisme d'Etrainement du Generateur Solaire), and the MOGS (Mechanisme d'Orientation de Generateur Solaire), both solar array drive mechanisms. Key design areas and the mechanism performance obtained are highlighted. Some test problems with the MEGS sliprings are discussed. Author

N87-29869*# Sperry Space Systems, Durham, N.C.
COMMON DRIVE UNIT
R. C. ELLIS, R. A. FINK, and E. A. MOORE *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 145-163 May 1987
Avail: NTIS HC A16/MF A01 CSCL 13I

The Common Drive Unit (CDU) is a high reliability rotary actuator with many versatile applications in mechanism designs. The CDU incorporates a set of redundant motor-brake assemblies driving a single output shaft through differential. Tachometers provide speed information in the AC version. Operation of both motors, as compared to the operation of one motor, will yield the same output torque with twice the output speed. Author

N87-29879*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION LUBRICATION CONSIDERATIONS
LUBERT J. LEGER and KEITH DUFRANE (Battelle Columbus Labs., Ohio.) *In its* The 21st Aerospace Mechanisms Symposium p 285-294 May 1987
Avail: NTIS HC A16/MF A01 CSCL 22B

Future activities in space will require the use of large structures and high power availability in order to fully exploit opportunities in Earth and stellar observations, space manufacturing and the development of optimum space transportation vehicles. Although these large systems will have increased capabilities, the associated development costs will be high, and will dictate long life with minimum maintenance. The Space Station provides a concrete example of such a system; it is approximately one hundred meters in major dimensions and has a life requirement of thirty years. Numerous mechanical components will be associated with these systems, a portion of which will be exposed to the space environment. If the long life and low maintenance goals are to be satisfied, lubricants and lubrication concepts will have to be carefully selected. Current lubrication practices are reviewed with the intent of determining acceptability for the long life requirements. The effects of exposure of lubricants and lubricant binders to the space environment are generally discussed. Potential interaction of MoS2 with atomic oxygen, a component of the low Earth orbit environment, appears to be significant. Author

11

MATERIALS

Includes mechanical properties of materials, and descriptions and analyses of different structural materials, films, coatings, bonding materials and descriptions of the effects of natural and induced space environments.

A87-32059

THE VANDERBILT UNIVERSITY NEUTRAL O-BEAM FACILITY

C. L. JOHNSON, R. G. ALBRIDGE, A. V. BARNES, R. K. COLE, D. J. DEAN (Vanderbilt University, Nashville, TN) et al. SAMPE Quarterly (ISSN 0036-0821), vol. 18, Jan. 1987, p. 35-40. Research supported by Martin Marietta Corp. refs

As part of a study of the effects of atomic oxygen on spacecraft surfaces in low earth orbit, a novel method for the laboratory production of low-energy beams of neutral atomic oxygen by a facility that uses a mixture of 90 percent helium and 10 percent oxygen was developed. Beams of He(+), O(+), and O2(+) ions produced by the facility are extracted, accelerated, and mass-selected by crossed electric and magnetic fields. Neutralization of the decelerated beams is accomplished by means of an electron transfer from a flat metal surface which the beams strike at a grazing-incidence angle. The procedure produces pure neutral atomic beams that are focused and monoenergetic. As examples of studies of the effects of atomic oxygen on space-relevant materials, the optical spectra resulting from interactions of a beam of 2.5-keV neutral oxygen atoms and a beam of 5.0-keV oxygen ions incident on a Kapton film sample are presented. I.S.

A87-32060

HIGH INTENSITY 5 EV CW LASER SUSTAINED O-ATOM EXPOSURE FACILITY FOR MATERIAL DEGRADATION STUDIES

J. B. CROSS, L. H. SPANGLER, M. A. HOFFBAUER, and F. A. ARCHULETA (Los Alamos National Laboratory, NM) SAMPE Quarterly (ISSN 0036-0821), vol. 18, Jan. 1987, p. 41-47. refs

An atomic oxygen exposure facility has been developed for studies of material degradation. The goal of these studies is to provide design criteria and information for the manufacture of long life (20 to 30 years) construction material for use in low earth orbit. The studies that are being undertaken using the facility will provide: (1) absolute reaction cross sections for use in engineering design problems, (2) formulations of reaction mechanisms for use in selection of suitable existing materials and design of new more resistant ones, and (3) calibration of flight hardware (mass spectrometers, etc.) in order to directly relate experiments performed in low earth orbit to ground based investigations. Author

A87-32061* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SELECTED MATERIALS ISSUES ASSOCIATED WITH SPACE STATION

L. LEGER, J. VISENTINE, and B. SANTOS-MASON (NASA, Johnson Space Center, Houston, TX) SAMPE Quarterly (ISSN 0036-0821), vol. 18, Jan. 1987, p. 48-54. refs

Compatibility of Space Station hardware with the space environment is one of the major materials development issues. The projected long life of the Space Station elements (about 30 years for structural components and 20 years for power systems), the large number of day/night thermal cycles that have to be withstood during the life of the Station, and the effects of atomic oxygen and UV irradiation on exposed surfaces demand new considerations in selection of materials. Reaction efficiencies of materials for Space Station applications derived from LEO experiments are presented together with surface recession predictions for various Space Station components. Developments in the areas of protective coatings and of laboratory facilities for evaluating the effects of atomic oxygen are discussed. I.S.

A87-32342

DEVELOPMENT OF GRAPHITE EPOXY SPACE STRUCTURE

MASANOBU YAMAGUCHI, KATSUHIDE KITAMURA, YOSHIKAZU OJIMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Space Development Div., Tokyo, Japan), and TASUKU YAMAGATA (Ishikawajima-Harima Heavy Industries Co., Ltd., Research Institute, Yokohama, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 509-514.

This paper describes application of graphite epoxy composites to truss type space structures. The design method of graphite epoxy tube is studied, and influences of the space environment on graphite epoxy composites are discussed. Fiber orientation of unidirectional laminae must be carefully selected in order to prevent transverse cracks from arising. A basic structure of truss type space structure which is 1.5 m long, 0.75 m wide, and 0.75 m high was manufactured. Author

A87-33100*# Rome Air Development Center, Hanscom AFB, Mass.

SPACECRAFT DIELECTRIC MATERIAL PROPERTIES AND SPACECRAFT CHARGING

A. R. FREDERICKSON, J. A. WALL (USAF, Rome Air Development Center, Bedford, MA), D. B. COTTS (SRI International, Menlo Park, CA), and F. L. BOUQUET (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Research supported by USAF and NASA. New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 107), 1986, 89 p. refs

The physics of spacecraft charging is reviewed, and criteria for selecting and testing semiinsulating polymers (SIPs) to avoid charging are discussed and illustrated. Chapters are devoted to the required properties of dielectric materials, the charging process, discharge-pulse phenomena, design for minimum pulse size, design to prevent pulses, conduction in polymers, evaluation of SIPs that might prevent spacecraft charging, and the general response of dielectrics to space radiation. SIPs characterized include polyimides, fluorocarbons, thermoplastic polyesters, poly(alkanes), vinyl polymers and acrylates, polymers containing phthalocyanine, polyacene quinones, coordination polymers containing metal ions, conjugated-backbone polymers, and 'metallic' conducting polymers. Tables summarizing the results of SIP radiation tests (such as those performed for the NASA Galileo Project) are included. T.K.

A87-33639#

EFFECT OF TRANSVERSE SHEARING FORCES ON BUCKLING AND POSTBUCKLING OF DELAMINATED COMPOSITES UNDER COMPRESSIVE LOADS

G. A. KARDOMATEAS and D. W. SCHMUESER (GM Research Laboratories, Warren, MI) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 757-765. refs

(AIAA PAPER 87-0877)

The deformation of delaminated composites under axial compression is analyzed by a one-dimensional beam-plate model. In this model, a formulation that accounts for the transverse shear effects is also presented. Using the perturbation technique, analytical solutions for the critical instability load and the postbuckling deflections are obtained. All possible instability modes, namely local delamination buckling, global plate buckling and coupled global and local (mixed) buckling are considered. Specific emphasis is placed on studying the transverse shear effects on both the critical load and the postcritical characteristics, as well as the influence of the geometry such as that of the location of the delamination across the thickness. The postbuckling solution is used in conjunction with a J-integral formulation to study the postcritical characteristics with respect to possible quasi-static extension of the delamination and the energy absorption capacity of a beam. Author

A87-38625* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PRODUCTION OF PULSED ATOMIC OXYGEN BEAMS VIA LASER VAPORIZATION METHODS

DAVID E. BRINZA, DANIEL R. COULTER, RANTY H. LIANG, and AMITAVA GUPTA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 769-779. refs

The generation of energetic pulsed atomic oxygen beams by laser-driven evaporation of cryogenically frozen ozone/oxygen films and thin indium-tin oxide (ITO) films is reported. Mass spectroscopy is used in the mass and energy characterization of beams from the ozone/oxygen films, and a peak flux of 3 x 10 to the 20th/sq m per sec at 10 eV is found. Analysis of the time-of-flight data suggests that several processes contribute to the formation of the oxygen beam. Results show the absence of metastable states such as the 2p(3)3s(1)(5S) level of atomic oxygen blown-off from the ITO films. The present process has application to the study of the oxygen degradation problem of LEO materials. R.R.

A87-38641* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DEGRADATION STUDIES OF SMRM TEFLON

RANTY H. LIANG, KERI L. ODA, SHIRLEY Y. CHUNG, and AMITAVA GUPTA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1050-1055.

Teflon samples returned from the Solar Max Satellite (SMS) suffered noticeable damage such as cracking and yellowing. This is in contrast to teflon exposed aboard STS-5 and STS-8 which showed no detectable changes. Selected teflon tape samples from SMS were studied to evaluate the extent and mechanism of degradation. ESCA studies revealed that these teflon samples contain hydrocarbon segments which were susceptible to oxygen atom degradation. Mechanical measurements also showed bulk property changes as a result of LEO exposure. A molecular model of material and energetic oxygen atom interaction was proposed. SMS data and the importance of developing correlation between accelerated exposure data from STS and ground-based testing and real time data will be presented. Author

A87-38642

STRUCTURE-PROPERTY RELATIONSHIPS IN POLYMER RESISTANCE TO ATOMIC OXYGEN

LARRY P. TORRE and H. GARY PIPPIN (Boeing Aerospace Co., Seattle, WA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1086-1100. refs

A theory based on the surface recombination of atomic oxygen is proposed to partially explain the degradation of materials in LEO, with application to the development of space-base materials. Such recombination processes can provide up to 5.07 eV to a chemical bond, and are shown to account for many of the observations of degradation. Previous results show the contribution of bond strengths (of greater than 4.2 eV), fluoridation, and bulky side groups to the resistance of certain polymers to attack by atomic oxygen. R.R.

A87-39426#

EFFECT OF LONG-TERM EXPOSURE TO LEO SPACE ENVIRONMENT ON SPACECRAFT MATERIALS

D. G. ZIMCIK (CDC, Communications Research Centre, Ottawa, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, March 1987, p. 4-10. refs

The resistance of some polymeric materials to the LEO environment is evaluated. Long-term exposure data obtained from components and materials from the SMM satellite are compared with data obtained from the Advanced Composite Material Exposure to Space Experiment flown Shuttle mission STS-41G. The Modular Attitude Control System for the SMM satellite, which contains Kapton, Teflon, and Chemglaze Z306, and specimens of Kapton and Chemglaze Z306 from the STS-41G mission are analyzed. It is observed that the reaction rate for surface degradation of Kapton in both experiments correlate well. The changes in the morphology of the silver-backed Teflon second surface mirrors of the SMM satellite are examined. The absorptance/emittance ratio for Kapton, Teflon, and Chemglaze Z306 are calculated and studied. The data reveal that there are changes in the Kapton and Teflon ratios; however, for the Chemglaze no significant differences in the absorptance/emittance ratio are detected. I.F.

A87-41022

MICROCRACK RESISTANT STRUCTURAL COMPOSITE TUBES FOR SPACE APPLICATIONS

HENRY W. BABEL, TIMOTHY P. SHUMATE, and DANIEL F. THOMPSON (McDonnell Douglas Astronautics Co., Huntington Beach, CA) SAMPE Journal (ISSN 0091-1062), vol. 23, May-June 1987, p. 43-48. refs

A program was initiated and is continuing to evaluate and select carbon fiber/resin combinations which would not microcrack when exposed to the temperature variations encountered in space. Service temperatures were analytically predicted for anodized aluminum and Teflon coatings. Proven MY720/DDS type resins, new toughened resins with high residual compression strength after impact and resins which permit low cost processing were selected for evaluation. A 1000-cycle screening test program from room temperature to -157 C was initiated to evaluate the microcracking resistance of the candidate resins. Selected candidates will be identified for a long term verification test program in which cyclic temperatures expected in space will be used. Three of the material systems tested during 1986 exhibited test induced microcracking. Several of the test specimens that cracked had processing related defects present prior to testing. Additional testing will be conducted during 1987 to determine if the preexisting defects contributed to the observed cracking. Author

A87-44741

MATERIALS FOR SPACE APPLICATIONS

M. D. JUDD (ESA, Product Assurance Div., Noordwijk, Netherlands) IN: Materials in aerospace; Proceedings of the First International Conference, London, England, Apr. 2-4, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 240-248.

An account is given of aerospace industry performance requirements for materials that are to be subjected to orbital space conditions as constituents of such spacecraft as Columbus and Hermes. The residual oxygen atoms in low earth orbit can drastically degrade a number of otherwise structurally useful polymeric materials; such effects will be felt in combination with high UV ionizing radiation fluxes, vacuum-outgassing conditions, etc. Instances of materials currently being developed to meet space requirements are solar cell and cover glass adhesives with low outgassing properties, conductive and nonconductive thermal control paints with good UV radiation stability, and UV exposure-curing resin systems for inflatable antenna construction. O.C.

A87-49797* Massachusetts Inst. of Tech., Cambridge.

MATERIAL DAMPING IN ALUMINUM AND METAL MATRIX COMPOSITES

EDWARD F. CRAWLEY and MARTHINUS C. VAN SCHOOR (MIT, Cambridge, MA) Journal of Composite Materials (ISSN 0021-9983), vol. 21, June 1987, p. 553-568. Research supported by Textron, Inc. refs
(Contract NAGW-21)

The material damping in beam-like specimens of aluminum and metal matrix composites was measured. A unique apparatus to determine damping by free decay while the specimens are in free fall in a vacuum was used. The specimens tested include 2024-T3 and 6061-T4 aluminum, and unidirectional graphite/metal matrix specimens with P55 and P100 fibers and 6061 Aluminum and AZ91C Magnesium as matrix materials. Tests were conducted to determine the dependence of damping on frequency and stress level. For the aluminum specimens, the material damping followed the Zener model at very low stress levels. Below the Zener relaxation frequency, a strong dependence of damping on stress was found for even moderate stress levels. Damping for the aluminum matrix materials was slightly above that predicted by the Zener model for a homogeneous bar of the matrix aluminum. For the magnesium matrix specimens, damping significantly above the Zener prediction for the homogeneous matrix material was observed. Author

A87-51772

DEVELOPMENT OF METAL MATRIX COMPOSITES IN R & D INSTITUTE OF METALS & COMPOSITES FOR FUTURE INDUSTRIES

YOSHIO MINODA (Research and Development Institut of Metals and Composites for Future Industries, Tokyo, Japan) IN: Composites '86: Recent advances in Japan and the United States; Proceedings of the Third Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 23-25, 1986 . Tokyo, Japan Society for Composite Materials, 1986, p. 475-481. refs

The latest status of a research and development program to develop basic industrial technology for metal matrix composites suitable for aerospace structures in the 1990's is discussed. Findings to date and remaining problems in the three parts of the program are summarized, including the development of graphite/Al and SiC (Nicalon)/Al preformed wires, the development of primary forming technology for them, and related structural or quality evaluation technologies necessary for application to end items. It has been found that both aluminum-infiltrated graphite and SiC (Nicalon) yarn seem to be very useful intermediate material for producing metal matrix composites. Titanium matrix composites show superior mechanical properties compared to aluminum matrix composites. C.D.

A87-51794

TAYLORED LAMINATES WITH NULL OR ARBITRARY COEFFICIENT OF THERMAL EXPANSION

TAKASHI ISHIKAWA and HISAO FUKUNAGA (National Aerospace Laboratory, Chofu, Japan) IN: Composites '86: Recent advances in Japan and the United States; Proceedings of the Third Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 23-25, 1986 . Tokyo, Japan Society for Composite Materials, 1986, p. 701-708. refs

A lamination tayloring theory is proposed in order to control the coefficient of thermal expansion of graphite/epoxy composites in a principal direction. This technique consists of the concepts of thermoelastic invariants and lamination parameters. The expansion-free condition yields to a parabola in the feasible region of the lamination parameters. The calculated curves for a wide range of temperature intersect almost at a point. A laminate with the lay-up construction corresponding to this point will exhibit an approximately null coefficient in one direction in that temperature range. Some preliminary experimental results indicate that the present procedure is possible and promising. The taylored material will be appropriate for the Space Station. Author

A87-53946

TESTING OF MATERIALS FOR SOLAR POWER SPACE APPLICATIONS

BRUCE J. FARADAY, RICHARD L. STATLER, and DELORES H. WALKER (U.S. Navy, Naval Research Laboratory, Washington, DC) Solar Energy Materials (ISSN 0165-1633), vol. 15, July 1987, p. 313-336. refs

This paper summarizes the results of a program initiated at the Naval Research Laboratory to test conventional and state-of-the-art solar power space systems by flying them aboard satellites. The program confirmed the practicality of improvements in advanced Si solar cells such as textured surfaces, shallow junctions, back surface field, and back surface reflector techniques. The performance of GaAlAs solar cells was demonstrated to be satisfactory. Finally, advanced Si cells such as Li-diffused and vertical junction cells were found unsuitable for extended space application. Author

N87-23736* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OXIDATION PROTECTION COATINGS FOR POLYMERS Patent

JAMES S. SOVEY, inventor (to NASA), BRUCE A. BANKS, inventor (to NASA), and MICHAEL J. MIRTICH, inventor (to NASA) 12 May 1987 7 p Filed 27 Feb. 1986 Supersedes N86-26434 (24 - 17, p 2709)

Division of US-Patent-4,604,181, Patent-Appl-SN-761235, which is a division of US-Patent-4,560,577, US-Patent-Appl-SN-649330

(NASA-CASE-LEW-14072-3; US-PATENT-4,664,980;
US-PATENT-APPL-SN-834977; US-PATENT-CLASS-428-421;
US-PATENT-CLASS-428-422; US-PATENT-CLASS-428-447;
US-PATENT-CLASS-428-473.5; US-PATENT-CLASS-428-702)
Avail: US Patent and Trademark Office CSCL 11B

A polymeric substrate is coated with a metal oxide film to provide oxidation protection in low Earth orbital environments. The film contains about four volume percent polymer to provide flexibility. NASA

N87-25430# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

FIBER COMPOSITES IN SATELLITES

ARMIN SCHEDLER 28 Jul. 1986 16 p Presented at the Conference on ICMC Nonmetallic Materials and Composites at Low Temperatures 4, Heidelberg, West Germany, 28-29 Jul. 1986 (MBB-UD-492/86; ETN-87-99932) Avail: Issuing Activity

The advantages of the low specific weight, high strength, and adjustable values of stiffness, thermal expansion, and thermal conductivity of fiber composites for spacecraft construction are reviewed. Utilizations between 4 and 450K are illustrated. ESA

N87-25490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EVALUATION OF CANDIDATE OXIDATION RESISTANT MATERIALS FOR SPACE APPLICATIONS IN LEO

SHARON RUTLEDGE, BRUCE BANKS, FRANK DIFILIPPO, JOYCE BRADY, THERESE DEVER, and DEBORAH HOTES (Cleveland State Univ., Ohio.) 1986 16 p Presented at the Workshop on Atomic Oxygen Effects, Pasadena, Calif., 10-11 Nov. 1986; sponsored by JPL

(NASA-TM-100122; E-3669; NAS 1.15:100122) Avail: NTIS HC A02/MF A01 CSCL 11C

Ground based testing of materials considered for polyimide (Kapton) solar array blanket protection and graphite-epoxy structural member protection was performed in an RF plasma asher. Protective coatings on Kapton from various commercial sources and from NASA Lewis Research Center were exposed to the air plasma; and mass loss per unit area was measured for each sample. All samples evaluated provided some protection to the underlying surface, but metal-oxide-fluoropolymer coatings provided the best protection by exhibiting very little degradation after 47 hr of asher exposure. Mica paint was evaluated as a protective coating for graphite-epoxy structural members. Mica appeared to be resistant to attack by atomic oxygen, but only offered limited protection as a paint. this is believed to be due to the paint vehicle ashing underneath the mica leaving unattached mica flakes lying on the surface. The protective coatings on Kapton evaluated so far are promising but further research on protection of graphite-epoxy support structures is needed. Author

N87-25596*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

BI-STEM GRIPPING APPARATUS Patent Application

FRED G. SANDERS, inventor (to NASA) 3 Jun. 1987 13 p
(NASA-CASE-MFS-28185-1; US-PATENT-APPL-SN-056930)
Avail: NTIS HC A02/MF A01 CSCL 13I

This invention relates to devices which grip cylindrical structures and more particularly to a device which has three arcuate gripping members having frictional surfaces for gripping and compressing a bi-stem. The bi-stem gripping apparatus is constructed having a pair of side gripping members, and an intermediate gripping member disposed between them. Sheets of a gum stock silicone rubber with frictional gripping surfaces are bonded to the inner region of the gripping members and provide frictional engagement between the bi-stem and the apparatus. A latch secures the gripping apparatus to a bi-stem, and removable handles are attached, allowing an astronaut to pull the bi-stem from its cassette. A tethering ring on the outside of the gripping apparatus provides a convenient point to which a lanyard may be attached. NASA

N87-26175*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

MATERIAL INTERACTIONS WITH THE LOW EARTH ORBITAL (LEO) ENVIRONMENT: ACCURATE REACTION RATE MEASUREMENTS

JAMES T. VISENTINE and LUBERT J. LEGER *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 11-20 1 Jun. 1987

Avail: NTIS HC A09/MF A01 CSCL 07D

To resolve uncertainties in estimated LEO atomic oxygen fluence and provide reaction product composition data for comparison to data obtained in ground-based simulation laboratories, a flight experiment has been proposed for the space shuttle which utilizes an ion-neutral mass spectrometer to obtain in-situ ambient density measurements and identify reaction products from modeled polymers exposed to the atomic oxygen environment. An overview of this experiment is presented and the methodology of calibrating the flight mass spectrometer in a neutral beam facility prior to its use on the space shuttle is established. The experiment, designated EOIM-3 (Evaluation of Oxygen Interactions with Materials, third series), will provide a reliable materials interaction data base for future spacecraft design and will furnish insight into the basic chemical mechanisms leading to atomic oxygen interactions with surfaces. M.G.

N87-26177*# Alabama Univ., Huntsville. Dept. of Chemistry.

INTERACTION OF HYPERTHERMAL ATOMS ON SURFACES IN ORBIT: THE UNIVERSITY OF ALABAMA EXPERIMENT

J. C. GREGORY *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 29-36 1 Jun. 1987

(Contract NAGW-823; NAGW-812)

Avail: NTIS HC A09/MF A01 CSCL 07D

The University of Alabama experiment which flew on the STS-8 mission had several objectives which were mostly of a speculative nature since so little was known of the processes of interest. The experiment provided original data on: (1) oxidation of metal surfaces; (2) reaction rates of atomic oxygen with carbon and other surfaces and the dependence of these rates on temperature; and (3) the angular distribution of 5 eV atoms scattered off a solid surface. A review of the results is provided. Author

N87-26180*# Yale Univ., New Haven, Conn. Dept. of Chemical Engineering.

PRODUCT ENERGY DISTRIBUTIONS AND ENERGY PARTITIONING IN O ATOM REACTIONS ON SURFACES

BRET HALPERN and MORIS KORI *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 55-62 1 Jun. 1987

(Contract NSF CPE-81-14348; PRF-17006-AC5-C; F49620-80-C-0026)

Avail: NTIS HC A09/MF A01 CSCL 07D

Surface reactions involving O atoms are likely to be highly exoergic, with different consequences if energy is channeled mostly to product molecules or surface modes. Thus the surface may become a source of excited species which can react elsewhere, or a sink for localized heat deposition which may disrupt the surface. The vibrational energy distribution of the product molecule contains strong clues about the flow of released energy. Two instructive examples of energy partitioning at surfaces are the Pt catalyzed oxidations: (1) C(ads) + O(ads) yields CO* (T is greater than 1000 K); and (2) CO(ads) + O(gas) yields CO2* (T is approx. 300 K). The infrared emission spectra of the excited product molecules were recorded and the vibrational population distributions were determined. In reaction 1, energy appeared to be statistically partitioned between the product CO and several Pt atoms. In reaction 2, partitioning was non-statistical; the CO2 asymmetric stretch distribution was inverted. In gas reactions these results would indicate a long lived and short lived activated complex. The requirement that Pt be heated in O atoms to promote reaction of atomic O and CO at room temperature is specifically addressed. Finally, the fraction of released energy that is deposited in the catalyst is estimated. M.G.

N87-26182*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

POTENTIAL ENERGY SURFACES FOR ATOMIC OXYGEN REACTIONS: FORMATION OF SINGLET AND TRIPLET BIRADICALS AS PRIMARY REACTION PRODUCTS WITH UNSATURATED ORGANIC MOLECULES

RICHARD L. JAFFE *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 75-87 1 Jun. 1987

Avail: NTIS HC A09/MF A01 CSCL 07D

The experimental study of the interaction of atomic oxygen with organic polymer films under LEO conditions has been hampered by the inability to conduct detailed experiments in situ. As a result, studies of the mechanism of oxygen atom reactions have relied on laboratory O-atom sources that do not fully reproduce the orbital environment. For example, it is well established that only ground electronic state O atoms are present at LEO, yet most ground-based sources are known to produce singlet O atoms and molecules and ions in addition to O(3P). Engineers should not rely on such facilities unless it can be demonstrated either that these different O species are inert or that they react in the same fashion as ground state atoms. Ab initio quantum chemical calculations have been aimed at elucidating the biradical intermediates formed during the electrophilic addition of ground and excited-state O atoms to carbon-carbon double bonds in small olefins and aromatic molecules. These biradicals are critical intermediates in any possible insertion, addition and elimination reaction mechanisms. Through these calculations, we will be able to comment on the relative importance of these pathways for O(3P) and O(1D) reactions. The reactions of O atoms with ethylene and benzene are used to illustrate the important features of the mechanisms of atomic oxygen reaction with unsaturated organic compounds and polymeric materials. Author

N87-26189*# Physical Sciences, Inc., Andover, Mass.

PULSED SOURCE OF ENERGETIC ATOMIC OXYGEN

GEORGE E. CALEDONIA and ROBERT H. KRECH *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 135-142 1 Jun. 1987

(Contract NAS7-936)

Avail: NTIS HC A09/MF A01 CSCL 07D

A pulsed high flux source of nearly monoenergetic atomic oxygen was designed, built, and successfully demonstrated. Molecular oxygen at several atmospheres pressure is introduced into an evacuated supersonic expansion nozzle through a pulsed molecular beam valve. An 18 J pulsed CO2 TEA laser is focused to intensities greater than 10(9) W/sq cm in the nozzle throat to generate a laser-induced breakdown. The resulting plasma is heated in excess of 20,000 K by a laser supported detonation wave, and then rapidly expands and cools. Nozzle geometry confines the expansion to provide rapid electron-ion recombination into atomic oxygen. Average O atom beam velocities from 5 to 13 km/s were measured at estimated fluxes to 10(18) atoms per pulse. Preliminary materials testing has produced the same surface oxygen enrichment in polyethylene samples as obtained on the STS-8 mission. Scanning electron microscope examinations of irradiated polymer surfaces reveal an erosion morphology similar to that obtained in low Earth orbit, with an estimated mass removal rate of approx. 10(-24) cu cm/atom. The characteristics of the O atom source and the results of some preliminary materials testing studies are reviewed. Author

N87-26190*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PRODUCTION OF PULSED ATOMIC OXYGEN BEAMS VIA LASER VAPORIZATION METHODS

DAVID E. BRINZA, DANIEL R. COULTER, RANTY H. LIANG, and AMITAVA GUPTA *In its* Proceedings of the NASA Workshop on Atomic Oxygen Effects p 143-150 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 20E

Energetic pulsed atomic oxygen beams were generated by laser-driven evaporation of cryogenically frozen ozone/oxygen films and thin films of indium-tin oxide (ITO). Mass and energy characterization of beams from the ozone/oxygen films were carried out by mass spectrometry. The peak flux, found to occur at 10 eV, is estimated from this data to be 3 x 10(20) m(-2) s(-1). Analysis of the time-of-flight data indicates a number of processes contribute to the formation of the atomic oxygen beam. The absence of metastable states such as the 2p(3) 3s(1) (5S) level of atomic oxygen blown off from ITO films is supported by the failure to observe emission at 777.3 nm from the 2p(3) 3p(1) (5P sub J) levels. Reactive scattering experiments with polymer film targets for atomic oxygen bombardment are planned using a universal crossed molecular beam apparatus. Author

N87-26197*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

REACTIONS OF ATOMIC OXYGEN (O(P-3)) WITH POLYBUTADIENES AND RELATED POLYMERS Abstract Only

MORTON A. GOLUB, NARCINDA R. LERNER, and THEODORE WYDEVEN *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 161 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 11B

Thin films of the following polymers were exposed at ambient temperature to ground-state oxygen atoms (O(P-3)), generated by a radio-frequency glow discharge in O2: cis- and trans-1,4-polybutadienes (CB and TB), amorphous 1,2-polybutadiene (VB), polybutadienes with different 1,4/1,2 contents, trans polypentenamer (TP), cis and trans polyoctenamers (CO and TO), and ethylene-propylene rubber (EPM). Transmission infrared spectra of CB and TB films revealed extensive surface recession, or etching, unaccompanied by any microstructural changes within the films, demonstrating that the reactions were confined to the surface layers. Contrary to the report by Rabek, Lucki, and Ranby (1979), there was no O(3P)-induced cis-trans isomerization in CB or TB. From weight-loss measurements, etch rates for polybutadienes were found to be markedly dependent on vinyl content, decreasing by two orders of magnitude from CB (2% 1,2) to structures with 30 to 40% 1,2 double bonds, thereafter increasing by half an order of magnitude to VB (97% 1,2). Relative etch rates for EMP and the polyalkenamers were in the order: EMP is greater than CO (or TO) is greater than TP is greater than CB. The sole non-elastomer examined, TB, had an etch rate about six times that of CB, ascribable to a morphology difference. Cis/trans content had a negligible effect on the etch rate of the polyalkenamers. Mechanisms involving crosslinking through units are proposed for the unexpected protection imparted to polybutadienes by the 1,2 double bonds. Author

N87-26198*# Physical Sciences, Inc., Andover, Mass.

CHEMICAL INTERACTIONS IN LOW EARTH ORBIT (LEO) Abstract Only

B. D. GREEN *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 162 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Although several observations of material changes on-orbit have been reported, mechanistic understanding has not yet become clear because new sets of non-intuitive processes are occurring on orbit. Reactant kinetic energy, low collision rates and surface/adsorbate interactions must be considered in the analysis of these observations. The specific example of oxide formation of elemental materials is examined in terms of thermodynamics and possible reaction pathways. On the basis of this approach, a rational trend emerges from the orbital behavior of these samples. The role of reactant kinetic energy as opposed to internal energy in chemiluminescent product formation is also presented. Development of a systematic thermochemical approach may be useful in making screening predictions of long-term material behavior on-orbit. Author

N87-26200*# Princeton Univ., N. J. Plasma Physics Lab.

GROUNDBASED STUDIES OF SPACECRAFT GLOW AND EROSION CAUSED BY IMPACT OF OXYGEN AND NITROGEN BEAMS Abstract Only

W. D. LANGER, S. A. COHEN, D. M. MANOS, R. W. MOTLEY, and S. F. PAUL *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 164 1 Jun. 1987
(Contract NAG8-521)
Avail: NTIS HC A09/MF A01 CSCL 22B

To simulate surface reactions in the space environment a ground-based facility was developed that produces a very high flux 10(14) to 10(16)/sq cm/s of low energy (2 to 20 eV) neutral atoms and molecules. The neutral beams are created using a method involving neutralization and reflection of ions from a biased limiter, where the ions are extracted from a toroidal plasma source. The spectra of emission due to beam-solid interactions on targets of Chemglaze Z-306 optical paint and Kapton are presented. Erosion yields for carbon and Kapton targets with low energy (approx. 10 eV) nitrogen and oxygen beams were measured. The reaction rates and surface morphology for the erosion of Kapton are similar to those measured in experiments on STS-5. Author

N87-26201*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

POTENTIAL SURFACES FOR O ATOM-POLYMER REACTIONS Abstract Only

B. C. LASKOWSKI (Analatom, Inc., San Jose, Calif.) and R. L. JAFFE *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 165 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Ab initio quantum chemistry methods are used to study the energetics of interactions of O atoms with organic compounds. Polyethylene (CH2)n has been chosen as the model system to study the interactions of O(3P) and O(1D) atoms with polymers. In particular, H abstraction is investigated and polyethylene is represented by a C3 (propane) oligomeric model. The gradient method, as implemented in the GRADSCF package of programs, is used to determine the geometries and energies of products and reactants. The saddle point, barrier geometry is determined by minimizing the squares of the gradients of the potential with respect to the internal coordinates. To correctly describe the change in bonding during the reaction at least a two configuration MCSCF (multiconfiguration self consistent field) or GVB (generalized valence bond) wave function has to be used. Basis sets include standard Pople and Dunning sets, however, increased with polarization functions and diffuse p functions on both the C and O atoms. The latter is important due to the O(-) character of the wave function at the saddle point and products. Normal modes and vibrational energy levels are given for the reactants, saddle points and products. Finally, quantitative energetics are obtained by implementing a small CAS (complete active space) approach followed by limited configuration interaction (CI) calculations. Comparisons are made with available experimental data. Author

N87-26202*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

NASA MARSHALL SPACE FLIGHT CENTER ATOMIC OXYGEN INVESTIGATIONS Abstract Only

In Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 166 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

An overview of the MSFC atomic oxygen investigations is provided, including descriptions of flight studies, ground-based testing, contractual efforts, and future focus. Summary results of

flight experiments on STS-5, STS-8, and STS 41-G are presented. The development of the MSFC Atomic Oxygen Resistive Monitor for the upcoming EOIM-3 (Evaluation of Oxygen Interaction with Materials 3) flight experiment is reviewed. Materials characterization work and ground-based testing are described. Contractual efforts, such as the development of atomic oxygen resistant coatings for the space station, are discussed. Future emphasis is placed on ground-based testing via the development and operation of a state-of-the-art atomic oxygen simulation system and on the continuation of flight studies in support of multi-programs.
Author

N87-26203*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN EVALUATION OF CANDIDATE OXIDATION RESISTANT MATERIALS Abstract Only
SHARON RUTLEDGE, BRUCE BANKS, MICHAEL MIRTICH, FRANK DIFILIPPO, DEBORAH HOTES, RICHARD LABED, TERESE DEVER, and MICHAEL KUSSMAUL (Cleveland State Univ., Ohio.) *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 167 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Ground based testing of materials considered for Kapton solar array blanket protection, graphite epoxy structural member protection, and high temperature radiators was performed in an RF plasma asher. Ashing rates for Kapton were correlated with rates measured on STS-8 to determine the exposure time equivalent to one year in low Earth orbit (LEO) at a constant density space station orbital flux. Protective coatings on Kapton from Tekmat, Andus Corporation, and LeRC were evaluated in the plasma asher and mass loss rates per unit area were measured for each sample. All samples evaluated provided some protection to the underlying surface but ion beam sputter deposited samples of SiO2 and SiO2 with 8% polytetrafluoroethylene (PTFE) showed no evidence of degradation after 47 hours of exposure. Mica paint was evaluated as a protective coating for graphite epoxy structural members. Mica appears to be resistant to attack by atomic oxygen but only offers some limited protection as a paint because the paint vehicles evaluated to date were not resistant to atomic oxygen. Four materials were selected for evaluation as candidate radiator materials: stainless steel, copper, niobium-1% zirconium, and titanium-6% aluminum-4% vanadium. These materials were surface textured by various means to improve their emittance. Emittances as high as 0.93 at 2.5 microns for stainless steel and 0.89 at 2.5 microns for Nb-1 Zr were obtained from surface texturing. There were no significant changes in emittance after asher exposure.
Author

N87-26206*# Boeing Aerospace Co., Seattle, Wash.
COMMENTS ON THE INTERACTION OF MATERIALS WITH ATOMIC OXYGEN Abstract Only
LARRY P. TORRE and H. GARY PIPPIN *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 170 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

An explanation of the relative resistance of various materials to attack by atomic oxygen is presented. Data from both ground based and on-orbit experiments is interpreted. The results indicate the importance of bond strengths, size and structure of pendant groups, and fluorination to the resistance of certain polymers to atomic oxygen. A theory which provides a partial explanation of the degradation of materials in low Earth orbit due to surface recombination of oxygen atoms is also included. Finally, a section commenting on mechanisms of material degradation is provided.
Author

N87-27909# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.
AROMATIC POLYESTER POLYSILOXANE BLOCK COPOLYMERS: MULTIPHASE TRANSPARENT DAMPING MATERIALS Final Report, 1 May 1984 - 30 Apr. 1985
JAMES E. MCGRATH 2 Oct. 1986 341 p
(Contract AF-AFOSR-0201-83)
(AD-A182623; AFOSR-87-0176TR) Avail: NTIS HC A15/MF A01 CSCL 11I

The synthesis and characterization of multiphase, transparent block copolymers that are potential candidates for passive damping applications in large space structures are described. Relatively high molecular weight polysiloxane-polyarylester block copolymers were prepared by two different synthetic routes. A solution technique was used to synthesize well-defined, perfectly alternating block copolymers by reacting a disfunctional hydroxyl-terminated polyarylester obligomer. A second approach involved the preparation of a segmented (or random) block copolymer by an interfacial, phase-transfer technique in which various polyarylester block lengths are formed during the copolymerization by reacting bisphenol-A, terephthaloyl chloride, and isophthaloyl chloride with a disfunctional aminopropyl-terminated siloxane block compositions (dimethyl, dimethyl-diphenyl, or dimethyl-trifluoro propylmethyl) were controlled. New siloxane-ester block copolymers were prepared and characterized. They are believed to be potentially useful materials for passive damping applications in the space environment.
GRA

N87-28584# IIT Research Inst., Chicago, Ill.
SPACE STABLE THERMAL CONTROL COATINGS Final Report, Sep. 1983 - Dec. 1986
R. J. MELL and Y. HARADA May 1987 177 p
(Contract F33615-83-K-5099)
(AD-A182796; IITRI-M06124-F; AFWAL-TR-87-4010) Avail: NTIS HC A09/MF A01 CSCL 11C

An important aspect of satellite operation in a space environment is thermal control design. Various coatings having desired optical properties have been used to achieve passive thermal control of different spacecraft. IITRI's S13G/LO coating has found widespread use in a number of missions for 15 years. The source of binder material for S13G/LO, however, is now unavailable and there is a continuing need on various spacecraft missions for this type of coating. This report covers research to develop and qualify a material having the same or improved optical and physical properties as S13G/LO. The coating was to display desirable and reliable behavior in a space environment. The study has resulted in a material designated, S13G/LO-1, which exhibits properties as good as, or somewhat better than the original S13G/LO. Environment, Satellite Thermal Control, Radiation Effects, Material Outgassing, Silicone Resin.
GRA

N87-29709# Aerospace Corp., El Segundo, Calif. Materials Sciences Lab.
EFFECTS ON ADVANCED MATERIALS: RESULTS OF THE STS-8 EOIM (EFFECTS OF OXYGEN INTERACTION WITH MATERIALS) EXPERIMENT
M. J. MESHISHNEK, W. K. STUCKEY, J. S. EVANGELIDES, L. A. FELDMAN, and R. V. PETERSON 20 Jul. 1987 89 p
(Contract F04701-85-C-0086)
(AD-A182931; TR-0086(6935-05)-2; SD-TR-87-34) Avail: NTIS HC A05/MF A01 CSCL 11D

A variety of materials were exposed to the low Earth orbit space environment on shuttle flight STS-8 as a part of NASA's Effects of Oxygen Atoms Interaction with Materials experiment. These materials include carbon and graphites, optical materials, organic and metal films, Kevlar and fiberglass fabric, and high-temperature coatings. The effects noted on these materials included oxidative erosion of the carbon and graphite, loss of tensile strength for the Kevlar fabric, erosion and oxidation of organic films, partial oxidation of infrared optical materials, and loss of reflectance for the high-temperature coatings.
GRA

12

INFORMATION AND DATA MANAGEMENT

Includes descriptions, requirements, and trade studies of different information and data system hardware and software, languages, architecture, processing and storage requirements for managing and monitoring of different systems and subsystems.

A87-31463
HEAD-PORTED DISPLAY ANALYSIS FOR SPACE STATION APPLICATIONS
KATHLEEN RADKE, PAMELA JAMAR, and LEE LEVITAN (Honeywell Systems and Research Center, Minneapolis, MN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 105-112.

This report describes the evaluation of the impact of using a head-ported display unit for Space Station activities. The technology survey identified applicable CRT and non-CRT display technologies suitable for a head-ported unit. A set of 14 crew task applications for head-ported displays was identified. A smaller set of high pay-off applications was then selected through analysis which included consideration for crew time spent in each activity, display requirements, visual, manual and verbal tasks performed while using the display, and the benefits a head-ported display would bring to the application compared to fixed or portable display configurations. Finally, the study evaluated the design impact that head-ported displays would have on the overall Space Station system. Author

A87-31519
ON THE PERFORMANCE ANALYSIS OF A REAL-TIME DISTRIBUTED COMPUTER SYSTEM
RAMI S. MANGOUBI, ELIEZER GAI (Charles Stark Draper Laboratory, Inc., Cambridge, MA), and BRUCE K. WALKER (MIT, Cambridge, MA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 529-535.

This paper is a continuation of a previous study, (Mangoubi et al., 1985) on the performance analysis of a special purpose real-time distributed computer system. The system must perform specific tasks that are repetitive and have known cycle or deadline times. Such systems arise in aerospace applications, where specific tasks, such as the calculation of feedback control signals, must be processed within a certain time period.Two performance indices are appropriate for such a system: the task delay times and the device or system utilization. The performance analysis is based on a queueing theory methodology. In this paper, results for the standard deviation of the delay times are given. Design issues and queue disciplines affecting performance are also discussed, and numerical results using a Space Station application as an example are presented. The results include a comparison among various queue disciplines. Author

A87-32075
EXPERT SYSTEMS IN SPACE
DAVID LEINWEBER (Inference Corp., Los Angeles, CA) IEEE Expert (ISSN 0885-9000), vol. 2, Spring 1987, p. 26-36. refs

The requirements of expert systems for monitoring and real-time control of processes on space platforms and the Space Station are described, along with a prototype system. Emphasis is on process intelligent control (PICON) written in Lisp, giving the expert system the capability of taking care of problems while maintaining operational continuity. Design criteria include rapid focusing on relevant sensors, fast data collection during critical events, analysis of the temporal history of sensor values, discerning the causes of anomalies from their effects through knowledge of the underlying process structure, and amenability to command sequence inputs. Techniques for using PICON to develop expert systems for specific roles and with the capability of interacting with other systems, for knowledge engineering, and to imbue the system with the ability to reason about data quality are explored. A sample application, control of the electrical power system for the Space Station, is outlined. M.S.K.

A87-33040
AN EVALUATION OF MENU SYSTEMS FOR SPACE STATION INTERFACES
JONATHAN F. ANTIN (Virginia Polytechnic Institute and State University, Blacksburg) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 679-683. refs

Menu systems are considered in terms of their ability to meet proposed basic requirements for Space Station interfaces. The following command modes are evaluated: (1) the direct mode, in which all commands are typed on a QWERTY keyboard (2) the menu mode, and (3) the hybrid mode which presented the same menus as were displayed in the menu mode, but commands could be selected from the menu via cursor control or typed in directly. It is concluded that the menu selection dialogue may be a useful and even preferred interactive environment for all levels of users; however, it must be well designed and flexible enough to meet their many needs. K.K.

A87-35282
COMPUTERIZED AEROSPACE MATERIALS DATA; PROCEEDINGS OF THE WORKSHOP ON COMPUTERIZED PROPERTY MATERIALS AND DESIGN DATA FOR THE AEROSPACE INDUSTRY, EL SEGUNDO, CA, JUNE 23-25, 1986
JACK H. WESTBROOK, ED. (Sci-Tech Knowledge Systems, Scotia, NY) and LOUIS R. MCCREIGHT, ED. (Aerospace Corp., El Segundo, CA) Workshop sponsored by the Aerospace Corp., Strategic Defense Initiative Organization, AIAA, et al. New York, American Institute of Aeronautics and Astronautics, Inc., 1987, 213 p. For individual items see A87-35283 to A87-35285.

Recommendations and guidelines are presented for the development of The National Materials Property Data Network. The underlying motivations for extablishing the Network are delineated, particularly its necessity for maintaining the competitiveness of U.S. industries. Providing on-line access to published technical documentation and research data, the Network subject matter will cover the physical, mechanical, corrosion and chemical properties of materials from indigenous and worldwise sources. The coverage will eventually extend to the optical and electrical properties of materials, along with access to hardcopy information. Information on metals, composites, polymers, structural materials for microapplications, ceramics and adhesives is to be available. Plans for the access procedures and the use interface are explored. Consideration is also given to applying CAD capabilities for integrated life-cycle planning during the design phase. M.S.K.

A87-37293*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION DATA MANAGEMENT SYSTEM ARCHITECTURE
WILLIAM E. MALLARY and VIRGINIA A. WHITELAW (NASA, Johnson Space Center, Houston, TX) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 320-328.

Within the Space Station program, the Data Management System (DMS) functions in a dual role. First, it provides the hardware resources and software services which support the data processing, data communications, and data storage functions of the onboard subsystems and payloads. Second, it functions as an integrating entity which provides a common operating environment and human-machine interface for the operation and control of the orbiting Space Station systems and payloads by both the crew and the ground operators. This paper discusses the evolution and derivation of the requirements and issues which have had significant effect on the design of the Space Station DMS, describes the DMS components and services which support system and payload operations, and presents the current architectural view of the system as it exists in October 1986; one-and-a-half years into the Space Station Phase B Definition and Preliminary Design Study.

Author

A87-37294*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SPACE STATION DATA MANAGEMENT SYSTEM - A COMMON GSE TEST INTERFACE FOR SYSTEMS TESTING AND VERIFICATION

PEDRO A. MARTINEZ and KEVIN W. DUNN (NASA, Johnson Space Center, Houston, TX) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 329-335. refs

This paper examines the fundamental problems and goals associated with test, verification, and flight-certification of man-rated distributed data systems. First, a summary of the characteristics of modern computer systems that affect the testing process is provided. Then, verification requirements are expressed in terms of an overall test philosophy for distributed computer systems. This test philosophy stems from previous experience that was gained with centralized systems (Apollo and the Space Shuttle), and deals directly with the new problems that verification of distributed systems may present. Finally, a description of potential hardware and software tools to help solve these problems is provided.

Author

A87-37431

STAR TOPOLOGY SPACECRAFT DATA BUS

ANTHONY G. GARAS (Sperry Corp., Space Systems Div., Glendale, AZ) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 727-736.

The projected NASA Space Station and SDI platforms will require distributed processing and real time control whose data communication networks' bus data rates will be of the order of 100-500 MBPS. A novel communications protocol is presented which furnishes a high data rate and very short transport delay performance; its implementation by means of a star topology fiber optic data bus has given attention to system robustness, redundancy, fault tolerance, autonomy, and error control. The performance of an eight-node demonstration network is assessed.

O.C.

A87-37968* Bell Telephone Labs., Inc., Murray Hill, N. J.

A CRISIS IN THE NASA SPACE AND EARTH SCIENCES PROGRAMME

LOUIS LANZEROTTI, J. (AT&T Bell Telephone Laboratories, Murray Hill, NJ), JEFFREY D. ROSENDHAL, DAVID C. BLACK (NASA, Washington, DC), D. JAMES BAKER (Joint Oceanographic Institutions, Inc., Washington, DC), PETER M. BANKS (Stanford University, CA), FRANCIS BRETHERTON (National Center for Atmospheric Research, Boulder, CO), ROBERT A. BROWN (Space Telescope Science Institute, Baltimore, MD), KEVIN C. BURKE (Lunar and Planetary Institute, Houston, TX), JOSEPH A. BURNS (Cornell University, Ithaca, NY), CLAUDE R. CANIZARES (MIT, Cambridge, MA) et al. Space Policy (ISSN 0265-9646), vol. 3, Feb. 1987, p. 38-51.

Problems in the space and earth science programs are examined. Changes in the research environment and requirements for the space and earth sciences, for example from small Explorer missions to multispacecraft missions, have been observed. The need to expand the computational capabilities for space and earth sciences is discussed. The effects of fluctuations in funding, program delays, the limited number of space flights, and the development of the Space Station on research in the areas of astronomy and astrophysics, planetary exploration, solar and space physics, and earth science are analyzed. The recommendations of the Space and Earth Science Advisory Committee on the development and maintenance of effective space and earth sciences programs are described.

I.F.

A87-40358

AN OPERATIONS MANAGEMENT SYSTEM FOR THE SPACE STATION

TERRY R. SAVAGE (TRW, Inc., Redondo Beach, CA) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 60-64. refs

A description is provided of an Operations Management System (OMS) for the planned NASA Space Station. The OMS would be distributed both in space and on the ground, and provide a transparent interface to the communications and data processing facilities of the Space Station Program. The allocation of OMS responsibilities has, in the most current Space Station design, been fragmented among the Communications and Tracking Subsystem (CTS), the Data Management System (DMS), and a redefined OMS. In this current view, OMS is less of a participant in the real-time processing, and more an overseer of the health and management of the Space Station operations.

Author

A87-40359

COMMUNICATION AND DATA MANAGEMENT SYSTEMS FOR AN ORBITING PLATFORM

WALTON CLARK (TRW, Inc., Cleveland, OH) and HOWARD KRAIMAN (General Electric Co., Fairfield, CT) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 65-71. refs

The Data Management System (DMS) provides the following services to an orbiting platform: (1) data distribution within and between core systems and payloads, (2) data processing facilities for core systems, (3) data base management, (4) time and frequency standards, and (5) overall platform management and control. The DMS is a distributed data processing network. The nodes are connected by a local area network. Each node is autonomous. Since the design is modular, nodes can be added or deleted without disturbing the system. Sensors and effectors communicate with the core system software via the network through multiplexers/demultiplexers.

Author

A87-40361

ON BOARD DATA MANAGEMENT

PAUL D. LILES and EDWARD V. DONG (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 270-275.

The Space Station is the next step in the U.S. space program. A key element of the Space Station is the on-board Data Management System (DMS). The DMS must provide a processing environment like that of a commercial or scientific ground computer system, but also support Station operations and missions like any airborne real-time avionics. At the same time, the DMS must be designed for growth and evolution. The fundamental architecture and functions of the DMS, however, have been defined. A brief overview is herein presented, based on current NASA concepts.

Author

A87-42821* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PROOF THAT TIMING REQUIREMENTS OF THE FDDI TOKEN RING PROTOCOL ARE SATISFIED

MARJORY J. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) IEEE Transactions on Communications (ISSN 0090-6778), vol. COM-35, June 1987, p. 620-625. refs

(Contract NAS2-11530)

The fiber distributed data interface (FDDI) is an ANSI draft proposed standard for a 100 Mbit/s fiber-optic token ring. The FDDI timed token access protocol provides dynamic adjustment of the load offered to the ring, with the goal of maintaining a specified token rotation time and of providing a guaranteed upper

bound on time between successive arrivals of the token at a station. FDDI also provides automatic recovery when errors occur. The bound on time between successive token arrivals is guaranteed only if the token rotates quickly enough to satisfy timer requirements in each station when all ring resources are functioning properly. Otherwise, recovery would be initiated unnecessarily. The purpose of this paper is to prove that FDDI timing requirements are satisfied, i.e., the token rotates quickly enough to prevent initiation of recovery unless there is failure of a physical resource or unless the network management entity within a station initiates the recovery process.
Author

A87-45485* LinCom Corp., Los Angeles, Calif.
FEASIBILITY STUDY ON 8PSK, QPSK, TFM, BY USING CLASS FOR SPACE STATION/TDRSS REAL MEASURED CHANNEL
SONG H. AN (LinCom Corp., Los Angeles, CA) and ROBERT D. GODFREY (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 150-154. refs
(Contract NAS5-29124)

The feasibility of transmitting 500 Mbps data rate through the TDRSS real channel (about 2.5 bits/sec/Hz) for the Space Station application is studied in this paper. The modulation schemes examined are octal phase shift keying, quarternary phase shift keying, and tamed frequency modulation scheme. The software tool used is the Communication Link Analysis and Simulation System. A channel equalizer is shown to be required for such application. Sensitivity results, eye diagrams, and phase trajectory diagrams are presented for discussions.
Author

A87-45521
A COST EFFECTIVE 300 MBPS SPACE-TO-GROUND COMMUNICATIONS SUBSYSTEM FOR THE SPACE STATION PROGRAM
PAUL R. JORDAN and PETER W. NILSEN (TRW, Inc., TRW Electronic Systems Group, Redondo Beach, CA) IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 826-831.

The design of a 300 Mbps space-to-ground communications subsystem (SGCS) for the Space Station is described. The SGCS is to provide forward link command and control channels between the ground, platforms, and Space Station, and the audio and video channels to the Space Station. The tracking and data relay satellite system is the main element for space-to-ground data flow; the SGCS is based on a Ku-band/X-band wideband data communication system. The data link requirements for the Space Station and its platforms are defined, and the development of cost-effective antennas for the Space Station and platforms is discussed. The components and capabilities of the RF and signal and data processing equipment of the SGCS are examined. Diagrams of the SGCS are presented.
I.F.

A87-48583#
PROCESS CONTROL AND DATA ACQUISITION FOR COMMERCIAL MATERIALS PROCESSING IN SPACE
EARL L. COOK (3M Co., Space Research and Applications Laboratory, Saint Paul, MN) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 7 p.
(AIAA PAPER 87-2197)

Process control and data acquisition requirements for the research, development, and manufacturing phases of materials processing in space are examined. It is determined that it is necessary for the data system to be hierarchical and distributed with well-defined interfaces between the various hierarchical levels, flexible, and capable of quick reprogramming and restructuring of experiments and acquiring and storing large amounts of data. A prototype system for the multiple secondary payloads on the Shuttle, the Payload Support Network (PSN), which allows simultaneous control of and operational interaction with multiple payloads connected in a network is proposed. The functions of the three major subsystems of the PSN, the crew interface, dedicated experiment processors, and an interconnection network, are described.
I.F.

A87-48587*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DATA STORAGE SYSTEMS TECHNOLOGY FOR THE SPACE STATION ERA
JOHN DALTON, FRED MCCALEB, JOHN SOS, JAMES CHESNEY, DAVID HOWELL (NASA, Goddard Space Flight Center, Greenbelt, MD) et al. AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 8 p.
(AIAA PAPER 87-2202)

The paper presents the results of an internal NASA study to determine if economically feasible data storage solutions are likely to be available to support the ground data transport segment of the Space Station mission. An internal NASA effort to prototype a portion of the required ground data processing system is outlined. It is concluded that the requirements for all ground data storage functions can be met with commercial disk and tape drives assuming conservative technology improvements and that, to meet Space Station data rates with commercial technology, the data will have to be distributed over multiple devices operating in parallel and in a sustained maximum throughput mode.
K.K.

A87-48588*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DATA CAPTURE AND PROCESSING
JOHN LYON, GENE SMITH, and RICHARD CARPER (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 14 p. refs
(AIAA PAPER 87-2203)

A systems concept developed in response to the specific requirements imposed by the Space Station and affiliated instrumentation is described. Particular attention is given to those subsystems associated with initial data capture, handling, routing, and distribution control for return link data via the Tracking and Data Relay Satellite System. The conceived approach, designated the Customer Data and Operations System, includes a data interface facility and a data handling center whose functions are data capture, demultiplexing and routing, early preprocessing, and ancillary data handling.
K.K.

A87-48589*# National Aeronautics and Space Administration, Washington, D.C.
THE CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS STANDARDS PROGRAM
S. RICHARD COSTA (NASA, Washington, DC) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 8 p. refs
(AIAA PAPER 87-2204)

The objectives of the Consultative Committee for Space Data Systems (CCSDS) include the identification of those common elements of space data systems which, if implemented in a standardized way, will significantly enhance the operation of future cooperative space missions. Recommendations of the CCSDS include packet telemetry and telecommand concepts, coding designs, ancillary data parameters and formats, and data exchange conventions. Consideration is given to the application of CCSDS recommendations.
K.K.

A87-48590#
DATA MANAGEMENT STANDARDS FOR SPACE INFORMATION SYSTEMS
R. DES JARDINS (Computer Technology Associates, Inc., McLean, VA) and C. MAZZA (ESA, European Space Operations Centre, Darmstadt, West Germany) AIAA and NASA, International

Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 7 p.
(AIAA PAPER 87-2205)

Data management - that is, storing, describing and retrieving data - is a special problem for the high performance bit-efficient information systems required for space missions. This paper presents a summary description of data management for space information systems, and describes four specific problem areas that can benefit from data management standards in the Space Station era: data description, data capture, data interchange, and data interpretation. In each area, a recommended modern data management standard or related technique is described as an example recommendation for future space information systems. The paper concludes with a recommendation that space agencies develop testbed validations of these 'new' approaches to data management. Author

A87-48593*# National Aeronautics and Space Administration, Washington, D.C.
THE SPACE STATION SOFTWARE SUPPORT ENVIRONMENT - NOT JUST WHAT, BUT WHY
JOHN R. GARMAN (NASA, Space Station Program Office, Washington, DC) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 22, 1987. 9 p. refs
(AIAA PAPER 87-2208)

The NASA environment is described with attention given to mission data systems in NASA and the strategic view. Space Station data systems are characterized into the following: distributed data systems, functionality and complexity, session oriented user interface, and distributed software development. The concept of a support software environment within the Space Station Program is elucidated and a strategic model for integrated data processing is presented. K.K.

A87-48600*# National Aeronautics and Space Administration, Washington, D.C.
TECHNICAL AND MANAGEMENT INFORMATION SYSTEM (TMIS)
TIMOTHY R. RAU (NASA, Washington, DC) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 10 p.
(AIAA PAPER 87-2217)

The TMIS goals developed to support the Space Station Program (SSP) mission requirements are outlined. The TMIS will provide common capabilities to all SSP centers and facilitate the flow of technical and management information throughout the program as well as SSP decision-making processes. A summary is presented of the various TMIS phases. K.K.

A87-48606*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION INFORMATION SYSTEM INTEGRATED COMMUNICATIONS CONCEPT
J. MURATORE, J. BIGHAM, V. WHITELAW, and W. MARKER (NASA, Johnson Space Center, Houston, TX) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 7 p.
(AIAA PAPER 87-2228)

This paper presents a model for integrated communications within the Space Station Information System (SSIS). The SSIS is generally defined as the integrated set of space and ground information systems and networks which will provide required data services to the Space Station flight crew, ground operations personnel, and customer communities. This model is based on the International Standards Organization (ISO) layered model for Open Systems Interconnection (OSI). The requirements used to develop the model are presented, and the various elements of the model described. Author

A87-48607*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION INFORMATION SYSTEM REQUIREMENTS FOR INTEGRATED COMMUNICATIONS
W. MARKER (NASA, Johnson Space Center, Houston, TX), V. WHITELAW, J. MURATORE, and J. BIGHAM, JR. AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 5 p.
(AIAA PAPER 87-2229)

Space Station Information System (SSIS) requirements for integrated end-to-end communications are presented. The SSIS is defined as the integrated set of space and ground data and information systems and networks which will provide required data services to the Space Station flight crew, ground operations personnel, and customer communities. This model is based on the International Standards Organization (ISO) layered model for Open System Interconnection (OSI). These SSIS requirements include grades of service, priority classifications, systems management, flow control, bandwidth allocation, and standard SSIS data services. Author

N87-20630# European Space Agency. ESRIN, Frascati (Italy).
PAYLOAD DATA MANAGEMENT SCHEME PLANNED FOR EARTH OBSERVATION SENSORS TO BE FLOWN ON THE POLAR PLATFORMS IN THE FRAMEWORK OF THE SPACE STATION/COLUMBUS PROGRAM
L. MARELLI *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 55-61 Nov. 1986
Avail: NTIS HC A07/MF A01

Data transmission to the ground from the Columbus polar platform; data acquisition and recording; data processing and dissemination; data archive/retrieval; and user interfaces are discussed. ESA

N87-20639# European Space Agency. ESRIN, Frascati (Italy).
DATA MANAGEMENT PANEL REPORT
L. MARELLI *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 101-102 Nov. 1986
Avail: NTIS HC A07/MF A01

Data gathering, data processing and dissemination, data archiving and retrieval, and user support services for the Columbus space station polar platforms are discussed. ESA

N87-23161*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SOT: A RAPID PROTOTYPE USING TAE WINDOWS
MARK STEPHENS, DAVID EIKE, ELFRIEDA HARRIS (Science Applications Research, Lanham, Md.), and DANA MILLER *In its* Sixth Annual Users' Conference p 97-110 Oct. 1986
Avail: NTIS HC A11/MF A01 CSCL 09B

The development of the window interface extension feature of the Transportable Applications Executive (TAE) is discussed. This feature is being used to prototype a space station payload interface in order to demonstrate and assess the benefits of using windows on a bit mapped display and also to convey the concept of telescience, the control and operation of space station payloads from remote sites. The prototype version of the TAE with windows operates on a DEC VAXstation 100. This workstation has a high resolution 19 inch bit mapped display, a keyboard and a three-button mouse. The VAXstation 100 is not a stand-alone workstation, but is controlled by software executing on a VAX/8600. A short scenario was developed utilizing the Solar Optical Telescope (SOT) as an example payload. In the scenario the end-user station includes the VAXstation 100 plus an image analysis terminal used to display the CCD images. The layout and use of the prototype elements, i.e., the root menu, payload status window, and target acquisition menu is described. M.G.

N87-24817*# California Univ., Santa Barbara. Information Sciences Research Group.
REMOTE SENSING INFORMATION SCIENCES RESEARCH GROUP: SANTA BARBARA INFORMATION SCIENCES RESEARCH GROUP, YEAR 4 Final Report
JOHN E. ESTES, TERENCE SMITH, and JEFFREY L. STAR 1 Jun. 1987 17 p
(Contract NAGW-455)
(NASA-CR-181073; NAS 1.26:181073) Avail: NTIS HC A02/MF A01 CSCL 05B

Information Sciences Research Group (ISRG) research continues to focus on improving the type, quantity, and quality of information which can be derived from remotely sensed data. Particular focus in on the needs of the remote sensing research and application science community which will be served by the Earth Observing System (EOS) and Space Station, including associated polar and co-orbiting platforms. The areas of georeferenced information systems, machine assisted information extraction from image data, artificial intelligence and both natural and cultural vegetation analysis and modeling research will be expanded. E.R.

N87-25890*# Stevens Inst. of Tech., Hoboken, N.J. Dept. of Electrical Engineering and Computer Science.
INTEGRATION OF COMMUNICATIONS AND TRACKING DATA PROCESSING SIMULATION FOR SPACE STATION
ROBERT C. LACOVARA *In* NASA. Lyndon B. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1986, Volume 2 11 p Jun. 1987
Avail: NTIS HC A13/MF A01 CSCL 17B

A simplified model of the communications network for the Communications and Tracking Data Processing System (CTDP) was developed. It was simulated by use of programs running on several on-site computers. These programs communicate with one another by means of both local area networks and direct serial connections. The domain of the model and its simulation is from Orbital Replaceable Unit (ORU) interface to Data Management Systems (DMS). The simulation was designed to allow status queries from remote entities across the DMS networks to be propagated through the model to several simulated ORU's. The ORU response is then propagated back to the remote entity which originated the request. Response times at the various levels were investigated in a multi-tasking, multi-user operating system environment. Results indicate that the effective bandwidth of the system may be too low to support expected data volume requirements under conventional operating systems. Instead, some form of embedded process control program may be required on the node computers. Author

N87-26057# Electronique Serge Dassault, St. Cloud (France).
STUDY OF EXPERT SYSTEM APPLICATIONS TO SPACE PROJECTS Final Report [ETUDE DE L'APPLICATION DES SYSTEMES EXPERTS AUX PROJETS SPATIAUX]
M. GUERIN Paris, France ESA 15 Jan. 1986 62 p In FRENCH
(Contract ESTEC-6028/84-NL-JS)
(NE-51-867; ESA-CR(P)-2316; ETN-87-99872) Avail: NTIS HC A04/MF A01

The applicability of artificial intelligence and expert systems to space projects is discussed and the potential utilization areas are identified, including thermal analysis, electric systems, optical systems, planning, design data bases, image processing, satellite control, orbit computations, launchers, space station diagnostics, maintenance, and project management. ESA

N87-26686*# City Univ. of New York, Bronx. Dept. of Physics.
DEVELOPMENT OF A COMPUTER PROGRAM TO GENERATE TYPICAL MEASUREMENT VALUES FOR VARIOUS SYSTEMS ON A SPACE STATION
LOUIS A. DEACETIS *In* NASA. Lyndon B. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1986, Volume 1 7 p Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 05A

The elements of a simulation program written in Ada were developed. The program will eventually serve as a data generator of typical readings from various space station equipment involved with Communications and Tracking, and will simulate various scenarios that may arise due to equipment malfunction or failure, power failure, etc. In addition, an evaluation of the Ada language was made from the viewpoint of a FORTRAN programmer learning Ada for the first time. Various strengths and difficulties associated with the learning and use of Ada are considered. Author

N87-27443*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MASS STORAGE SYSTEMS FOR DATA TRANSPORT IN THE EARLY SPACE STATION ERA 1992-1998
RICHARD CARPER, ed., JOHN DALTON, ed., MIKE HEALEY, ed., LINDA KEMPSTER, ed., JOHN MARTIN, ed. (Computer Technology Associates, Inc., Lanham, Md.), FRED MCCALEB, ed., STANLEY SOBIESKI, ed., and JOHN SOS, ed. July 1987 112 p
(NASA-TM-87826; REPT-87B0343; NAS 1.15:87826) Avail: NTIS HC A06/MF A01 CSCL 09B

NASA's Space Station Program will provide a vehicle to deploy an unprecedented number of data producing experiments and operational devices. Peak down link data rates are expected to be in the 500 megabit per second range and the daily data volume could reach 2.4 terabytes. Such startling requirements inspired an internal NASA study to determine if economically viable data storage solutions are likely to be available to support the Ground Data Transport segment of the NASA data system. To derive the requirements for data storage subsystems, several alternative data transport architectures were identified with different degrees of decentralization. Data storage operations at each subsystem were categorized based on access time and retrieval functions, and reduced to the following types of subsystems: First in First out (FIFO) storage, fast random access storage, and slow access with staging. The study showed that industry funded magnetic and optical storage technology has a reasonable probability of meeting these requirements. There are, however, system level issues that need to be addressed in the near term. Author

N87-28585# Selenia S.p.A., Rome (Italy).
DATA MANAGEMENT SYSTEM ARCHITECTURE OPTIONS FOR SPACE STATIONS Final Report
S. BOESSO, R. GAMBERALE, C. MONACO, L. HEFNER, and K. PEDERSEN Paris, France ESA 22 May 1987 460 p
(Contract ESTEC-5997/84-NL-PP(SC))
(SES/DNP/TR/002/85; ESA-CR(P)-2362; ETN-87-90466) Avail: NTIS HC A20/MF A01

The Columbus space station information system onboard function and requirements are summerized. Space Station Data Management (SSDMS) requirements (steady state and mission dependent) are given with quantification based on reference studies. Design and technology options concerning architecture, software, and SSDMS elements are presented and traded-off. A baseline for the initial SSDMS configuration is described and the growth capability is shown; diagnostic approach and validation and test concepts are discussed. Cost factors and critical elements of the SSDMS solution are defined; a program schedule and the required resources for study contracts to support development of the proposed configuration are outlined. ESA

N87-28586# MATRA Espace, Paris-Velizy (France).
STUDY OF DATA MANAGEMENT SYSTEM ARCHITECTURE OPTIONS FOR SPACE STATION Final Report
Paris, France ESA 18 Oct. 1985 227 p Prepared in cooperation with Messerschmitt Boelkow Blohm/Entwicklungsring Nord, Bremen, West Germany
(Contract ESTEC-5996/84-NL-PP(SC))
(MATRA-RF/176/0972-ISS-1; ESA-CR(P)-2363; ETN-87-90467) Avail: NTIS HC A11/MF A01

An approach to the Columbus space station which considers the Space Station Data Management System (SS-DMS) as a federation of local area DMS, interconnected through a wide area network is proposed. The European pressurized module DMS appears as one of the local area DMS, having well identified interfaces with the other local areas. The role of the gateway node in the coordination tasks between a local area and the remaining part of the space station is shown. The proposed local area architecture is compatible with the four Columbus elements, and the same type of LAN can be used in all four elements. An approach for scheduling the space station resource sharing is proposed, including a direct access concept. The production of quick looks on payload data is discussed. It is proposed to model the DMS with four types of functions: mission management, monitoring and reconfiguration, services, and resources. The fact that the resources and services are spread over the module causes the introduction of a distributed architecture concept. ESA

N87-29124*# National Aeronautics and Space Administration, Washington, D.C.
PROCEEDINGS: COMPUTER SCIENCE AND DATA SYSTEMS TECHNICAL SYMPOSIUM, VOLUME 1
RONALD L. LARSEN and KENNETH WALLGREN Aug. 1985
353 p Symposium held in Leesburg, Va., 16-18 Apr. 1985
(NASA-TM-89285; NAS 1.15:89285) Avail: NTIS HC A16/MF A01 CSCL 09B

Progress reports and technical updates of programs being performed by NASA centers are covered. Presentations in viewgraph form are included for topics in three categories: computer science, data systems and space station applications.

N87-29127*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DISTRIBUTED COMPUTER TAXONOMY BASED ON O/S STRUCTURE
EDWIN C. FOUDRIAT *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 1 10 p Aug. 1985
Avail: NTIS HC A16/MF A01 CSCL 09B

The taxonomy considers the resource structure at the operating system level. It compares a communication based taxonomy with the new taxonomy to illustrate how the latter does a better job when related to the client's view of the distributed computer. The results illustrate the fundamental features and what is required to construct fully distributed processing systems. The problem of using network computers on the space station is addressed. A detailed discussion of the taxonomy is not given here. Information is given in the form of charts and diagrams that were used to illustrate a talk. R.J.F.

N87-29128*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A WORKSTATION ENVIRONMENT FOR SOFTWARE ENGINEERING
SUSAN J. VOIGT *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 1 11 p Aug. 1985
Avail: NTIS HC A16/MF A01 CSCL 09B

Information on a workstation environment for software engineering is given in outline form. Tools that help software engineers, elements of the present system, and future plans are noted. R.J.F.

N87-29144*# National Aeronautics and Space Administration, Washington, D.C.
PROCEEDINGS: COMPUTER SCIENCE AND DATA SYSTEMS TECHNICAL SYMPOSIUM, VOLUME 2
RONALD L. LARSEN and KENNETH WALLGREN Aug. 1985
381 p Symposium held in Leesburg, Va., 16-18 Apr. 1985
(NASA-TM-89286; NAS 1.15:89286) Avail: NTIS HC A17/MF A01 CSCL 09B

Progress reports and technical updates of programs being performed by NASA centers are covered. Presentations in viewgraph form, along with abstracts, are included for topics in three categories: computer science, data systems, and space station applications.

N87-29145*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A VHSIC GENERAL PURPOSE PROCESSOR
H. F. BENZ *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 20 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

The very high speed integrated circuit (VHSIC) program offers NASA and its contractors assured availability of military specification embedded computer components and integrated computer aided design/computer aided engineering and software development support that result in low system life costs for data management systems on the space station and the Earth Observatory Satellite. Viewgraphs given review progress in both the Department of Defense VHSIC program and the NASA VHSIC related insertion development of a general purpose processor are presented. Author

N87-29146*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MAX: A SPACE STATION COMPUTER OPTION
D. B. SMITH and R. D. RASMUSSEN *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 12 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Information on Max, a space station computer option, is given in viewgraph form. The computer option is characterized by embedded, real-time applications; synchronous, cyclic operation and asynchronous, event driven operation; computationally intensive and data intensive processing; a wide range of throughput and memory requirements; a range of fault tolerant requirements from none to full; and maintainability, including capability for on-line substitution in critical systems. R.J.F.

N87-29148*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FLIGHT ARRAY PROCESSOR
In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 10 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Spaceflight applications for the NASA Scatterometer (NSCAT) , an ocean surface wind measuring system flown as part of the Navy Remote Ocean Sensing System (NROSS) are discussed in outline form, along with information on the Advanced Digital Synthetic aperture radar Processor (ADSP) that is being developed for ground-based processing of spacecraft Earth observations. Design considerations are listed. A block diagram of the scatterometer is given. R.J.F.

N87-29149*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFORMATION NETWORK ARCHITECTURES
N. D. MURRAY *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 25 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Graphs, charts, diagrams and outlines of information relative to information network architectures for advanced aerospace missions, such as the Space Station, are presented. Local area information networks are considered a likely technology solution. The principle needs for the network are listed. R.J.F.

N87-29150*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VIDEO IMAGE PROCESSING
N. D. MURRAY *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 25 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Current technology projections indicate a lack of availability of special purpose computing for Space Station applications. Potential functions for video image special purpose processing are being investigated, such as smoothing, enhancement, restoration and filtering, data compression, feature extraction, object detection and identification, pixel interpolation/extrapolation, spectral estimation and factorization, and vision synthesis. Also, architectural approaches are being identified and a conceptual design generated. Computationally simple algorithms will be research and their image/vision effectiveness determined. Suitable algorithms will be implimented into an overall architectural approach that will provide image/vision processing at video rates that are flexible, selectable, and programmable. Information is given in the form of charts, diagrams and outlines. Author

N87-29151*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FIBER OPTICS WAVELENGTH DIVISION MULTIPLEXING(COMPONENTS)
HERBERT D. HENDRICKS *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical symposium, Volume 2 13 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 20F

The long term objectives are to develop optical multiplexers/demultiplexers, different wavelength and modulation stable semiconductor lasers and high data rate transceivers, as well as to test and evaluate fiber optic networks applicable to the Space Station. Progress in each of the above areas is briefly discussed. Author

N87-29152*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
FIBER OPTIC DATA SYSTEMS
R. HARTENSTEIN *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 11 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 20F

An overview is given of a continuing data system architecture development effort. Accomplishments and states of Office of Aeronautics and Space Technology, NASA efforts are discussed, and possible future directions are briefly commented upon. Some performance data is presented on the access protocol utilized in the Bus Interface Unit (BIU) design effort, and it is compared with other access protocols. The status of the qualification effort is presented showing the successful qualification testing of cables, connectors, light emitting diodes and PIN diodes. Information is given in the form of charts and diagrams. Author

N87-29153*# National Aeronautics and Space Administration, Washington, D.C.
ADVANCED LOCAL AREA NETWORK CONCEPTS
TERRY GRANT *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 20 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Development of a good model of the data traffic requirements for Local Area Networks (LANs) onboard the Space Station is the driving problem in this work. A parameterized workload model is under development. An analysis contract has been started specifically to capture the distributed processing requirements for the Space Station and then to develop a top level model to simulate how various processing scenarios can handle the workload and what data communication patterns result. A summary of the Local Area Network Extendable Simulator 2 Requirements Specification and excerpts from a grant report on the topological design of fiber optic local area networks with application to Expressnet are given. Author

N87-29157*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NETWORK RELIABILITY
MARJORY J. JOHNSON *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 20 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Network control (or network management) functions are essential for efficient and reliable operation of a network. Some control functions are currently included as part of the Open System Interconnection model. For local area networks, it is widely recognized that there is a need for additional control functions, including fault isolation functions, monitoring functions, and configuration functions. These functions can be implemented in either a central or distributed manner. The Fiber Distributed Data Interface Medium Access Control and Station Management protocols provide an example of distributed implementation. Relative information is presented here in outline form. Author

N87-29160*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FIBER OPTICS COMMON TRANSCEIVER MODULE
HERBERT D. HENDRICKS *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 7 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 20F

The long term objectives are to develop a space qualified fiber optics transceiver for information networks applications on the Space Station, to advance the technology to increase the system data handling capability, to reduce the overall device size, and to improve efficiency and sensitivity. The characteristics of hybrid fiber optic transceivers and monolithic fiber optic transceivers are reviewed. Author

N87-29165*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SS FOCUSED TECHNOLOGY: GATEWAYS AND NOS'S
R. HARTENSTEIN *In* NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 7 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

The extensions and enhancements of the fiber optic data bus technology supported by the Space Station Focused Technology Program are discussed. This includes the operating software for the network called the Network Operating System (NOS); gateways and bridges for multiple network topologies; and very large scale topology implementations to shrink the size and power of the Bus Interface Unit (BIU) down to more manageable dimensions. CMOS is being investigated for the lower speed (parallel) logic. Gallium arsendide is being studied for the high speed (serial) logic. Author

N87-29166*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
NETWORK OPERATING SYSTEM
In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, volume 2 6 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

Long-term and short-term objectives for the development of a network operating system for the Space Station are stated. The short-term objective is to develop a prototype network operating system for a 100 megabit/second fiber optic data bus. The long-term objective is to establish guidelines for writing a detailed specification for a Space Station network operating system. Major milestones are noted. Information is given in outline form. R.J.F.

N87-29167*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NETWORK OPERATING SYSTEM FOCUS TECHNOLOGY
In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 10 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

An activity structured to provide specific design requirements and specifications for the Space Station Data Management System (DMS) Network Operating System (NOS) is outlined. Examples are given of the types of supporting studies and implementation tasks presently underway to realize a DMS test bed capability to

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develop hands-on understanding of NOS requirements as driven by actual subsystem test beds participating in the overall Johnson Space Center test bed program. Classical operating system elements and principal NOS functions are listed. Author

13

ACCOMMODATIONS

Includes descriptions of simulations, analyses, trade studies, and requirements for safe efficient procedures, facilities, and support equipment on the ground and in space for processing, servicing, maintenance, reliability, commonality, verification and checkout of cargo and equipment.

A87-32529
THE SPACE STATION - WORK PACKAGE 3
LARRY P. YERMACK (RCA, Astro-Electronics Div., Princeton, NJ) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1897-1904.

The features of the elements making up the U.S. Space Station Program are discussed. Emphasis is on Work Package 3, which has four elements: (1) two types of platforms (polar orbiting sun-synchronous platforms and platforms that coorbit at the same inclination as the Space Station Manned Base); (2) attached payload accommodations; (3) servicing requirements for the entire life cycle of the Space Station; and (4) laboratory module outfitting. Salient features of these elements are described together with the elements' functions. In addition, the details of the systems engineering and integration and the aspects of customer accommodation, product assurance, and advanced developments are discussed. I.S.

A87-32613
MAGNETIC REFRIGERATION FOR SPACE PLATFORMS
J. A. BARCLAY, F. C. PRENGER, W. F. STEWART, and C. B. ZIMM (Astronautics Corporation of America, Madison, WI) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p. refs
(SAE PAPER 861724)

Cryogenic systems will be a part of the Space Station and future space platforms in a variety of applications, such as propellant management and cooling of scientific instruments. The projected Space Station initial usage of cryogenic propellants is relatively small so the primary refrigeration need is for cooling scientific instruments and various sensors. A potential method for meeting these cooling requirements is the use of a refrigerator based on the temperature changes in certain magnetic materials upon application or removal of a magnetic field; i.e., the magnetocaloric effect. This type of refrigerator, known as a magnetic refrigerator, offers potentially higher reliability and lower power requirements than conventional refrigation units. Also, the higher power density of the magnetic refrigerator is an attractive feature for Space Station and space platform applications. Author

A87-33003* McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
THE USE OF MULTIDIMENSIONAL SCALING FOR FACILITIES LAYOUT - AN APPLICATION TO THE DESIGN OF THE SPACE STATION
THOMAS S. TULLIS, BARBRA BIED SPERLING, and A. L. STEINBERG (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 38-42. refs
(Contract NAS2-11723)

Before an optimum layout of the facilities for the proposed Space Station can be designed, it is necessary to understand the functions that will be performed by the Space Station crew and the relationships among those functions. Five criteria for assessing functional relationships were identified. For each of these criteria, a matrix representing the degree of association of all pairs of functions was developed. The key to making inferences about the layout of the Space Station from these matrices was the use of multidimensional scaling (MDS). Applying MDS to these matrices resulted in spatial configurations of the crew functions in which smaller distances in the MDS configuration reflected closer associations. An MDS analysis of a composite matrix formed by combining the five individual matrices resulted in two dimensions that describe the configuration: a 'private-public' dimension and a 'group-individual' dimension. Seven specific recommendations for Space Station layout were derived from analyses of the MDS configurations. Although these techniques have been applied to the design of the Space Station, they can be applied to the design of any facility where people live or work. Author

A87-33048
PLANNING FOR UNANTICIPATED SATELLITE SERVICING TELEOPERATIONS
JOHN R. RICE, JOHN P. YORCHAK, and CRAIG S. HARTLEY (Martin Marietta Corp., Denver, CO) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 870-874. refs

The role that man will play in the space-based servicing of satellites will change with standardization and automation of such operations. If history is any indication, man cannot be completely removed from servicing duties because unanticipated servicing operations occasionally will require his direct intervention and control through either extra-vehicular activities (EVA) or teleoperations. As a result, certain minimum user-system interface capabilities must be maintained, no matter how sophisticated future technology becomes. This paper discusses research related to some of the basic human factors problems that will probably always have an impact on space-based teleoperated servicing operations. The implicit warning is that future advanced systems must implement solutions to these problems if humans are to provide effective backup support. Furthermore, it is believed that there are several critical gaps in the present knowledge of teleoperator human factors that must be closed before such backup operations can be effective. There is a danger that system developers may become so enamored of advanced teleoperator technology that they may fail to provide an adequate user/system interface for backup operations. Human factors issues discussed include: vision systems, control devices, and communication time delays. Author

A87-38710* Life Systems, Inc., Cleveland, Ohio.
EDC DEVELOPMENT AND TESTING FOR THE SPACE STATION PROGRAM
R. B. BOYDA and S. P. HENDRIX (Life Systems, Inc., Cleveland, OH) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 75-86. NASA-sponsored research.
(SAE PAPER 860918)

NASA's development of electrochemical CO2 concentration technology has led to the creation of subsystem hardware and control and monitoring instrumentation that are ideally suited to Space Station program applications; only seven orbital replacement units, for instance, are required for the performance of process functions. This process simplification leads to superior reliability and enhanced maintainability. Hardware and software features that enhance subsystem reliability through fault detection and isolation have been emphasized in the course of development. Further power, weight, and volume savings, together with enhanced maintainability, are also foreseen in prospective developments of these subsystems. O.C.

A87-38722* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SPACE STATION GALLEY DESIGN

RUDY TRABANINO (NASA, Johnson Space Center, Houston, TX), GEORGE L. MURPHY, and M. M. YAKUT (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 201-206.
(SAE PAPER 860932)

An Advanced Food Hardware System galley for the initial operating capability (IOC) Space Station is discussed. Space Station will employ food hardware items that have never been flown in space, such as a dishwasher, microwave oven, blender/mixer, bulk food and beverage dispensers, automated food inventory management, a trash compactor, and an advanced technology refrigerator/freezer. These new technologies and designs are described and the trades, design, development, and testing associated with each are summarized. Author

A87-38742* General Electric Co., Philadelphia, Pa.

SCIENCE RESEARCH FACILITIES - VERSATILITY FOR SPACE STATION

J. A. GIANNOVARIO, J. D. SCHELKOPF, K. MASSEY, and M. SOLLY (General Electric Co., Space Div., Valley Forge, PA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 435-438.
(Contract NAS5-29300)
(SAE PAPER 860958)

The Space Station Science Lab Module (SLM) and its interfaces are designed to minimize complexity and maximize user accommodations. The facilities provided encompass life sciences research, the control of external payloads, the servicing of customer equipment, and general scientific investigations. The SLM will have the unprecedented ability to diagnose, service, and replace equipment while in orbit. In addition, the SLM will have significant operational advantages over previous spacecraft in terms of available volume, power, and crew interaction possibilities. O.C.

A87-38794* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

AN IMPROVED WASTE COLLECTION SYSTEM FOR SPACE FLIGHT

WILLIAM E. THORNTON, WILLIAM W. LOFLAND, JR. (NASA, Johnson Space Center, Houston, TX), and HENRY WHITMORE (Whitmore Enterprises, San Antonio, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 891-895. refs
(SAE PAPER 861014)

Waste collection systems are a critical part of manned space flight. Systems to date have had a number of deficiencies. A new system, which uses a simple mechanical piston compactor and disposable pads allows a clean area for defecation and maximum efficiency of waste collection and storage. The concept has been extensively tested. Flight demonstration units are being built, tested, and scheduled for flight. A prototype operational unit is under construction. This system offers several advantages over existing or planned systems in the areas of crew interface and operation, cost, size, weight, and maintenance and power consumption. Author

A87-40363

COMPLEX SYSTEM MONITORING AND FAULT DIAGNOSIS USING COMMUNICATING EXPERT SYSTEMS

J. Y. READ, T. P. HOWLAND, and W. A. PERKINS (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 102-109. refs

Using an enhanced version of the Lookheed Expert System, a communicating expert system for fault diagnosis and fault correction in a prototype for the Space Station Air Revitalization System was developed. The system consists of three communicating expert systems, one for oxygen generation; one for CO2 removal; and a supervisor for overall control. The three expert system modules communicate via mailboxes. The purpose of this work is to gain an understanding of the problems involved and advantages of using such a communicating expert systems framework. Author

A87-41870

EXPECTED SIZE OF A CRATER RESULTING FROM THE IMPACT OF A MICROMETEORITE [OZHIDAEMYI RAZMER KRATERA PRI UDARE MIKROMETEORITA]

M. M. RUSAKOV and M. A. LEBEDEV Fizika Goreniia i Vzryva (ISSN 0430-6228), vol. 23, Jan.-Feb. 1987, p. 95-98. In Russian. refs

An experimental study is made of the impact of a compact mass (a cylindrical cluster of tungsten particles with a density up to 1 g/cu cm) against targets of various structural materials, with impact velocities reaching 27 km/s. It is found that experimental results are adequately approximated, using the least squares method, by a linear relationship; the mean ejection velocity of the target mass is estimated at 1.5 km/s. The relationships presented here are also valid for spherical particles at impact velocities up to about 25 km/s. Calculations for targets of AMG6M aluminum alloy are presented. V.L.

A87-48582*# National Aeronautics and Space Administration, Washington, D.C.

SCIENTIFIC CUSTOMER NEEDS - NASA USER

DAVID C. BLACK (NASA, Washington, DC) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 4 p.
(AIAA PAPER 87-2196)

Some requirements for scientific users of the Space Station are considered. The use of testbeds to evaluate design concepts for information systems, and for interfacing between designers and builders of systems is examined. The need for an information system that provides an effective interaction between ground-based users and their space-based equipment is discussed. I.F.

A87-48597*# Ford Aerospace and Communications Corp., College Park, Md.

INTEGRATED SCHEDULING AND RESOURCE MANAGEMENT

M. T. WARD (Ford Aerospace and Communications Corp., College Park, MD) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 11 p. refs
(Contract NAS5-2750)
(AIAA PAPER 87-2213)

This paper examines the problem of integrated scheduling during the Space Station era. Scheduling for Space Station entails coordinating the support of many distributed users who are sharing common resources and pursuing individual and sometimes conflicting objectives. This paper compares the scheduling integration problems of current missions with those anticipated for the Space Station era. It examines the facilities and the proposed operations environment for Space Station. It concludes that the pattern of interdependecies among the users and facilities, which are the source of the integration problem is well structured, allowing a dividing of the larger problem into smaller problems. It proposes an architecture to support integrated scheduling by scheduling efficiently at local facilities as a function of dependencies with other facilities of the program. A prototype is described that is being developed to demonstrate this integration concept. Author

N87-20351*# McDonnell-Douglas Astronautics Co., St. Louis, Mo.

ADVANCED EVA SYSTEM DESIGN REQUIREMENTS STUDY: EVAS/SPACE STATION SYSTEM INTERFACE REQUIREMENTS

T. G. WOODS 15 Nov. 1985 122 p
(Contract NAS9-17299)
(NASA-CR-171981; NAS 1.26:171981; MDC-W0070) Avail: NTIS HC A06/MF A01 CSCL 22B

The definition of the Extravehicular Activity (EVA) systems interface requirements and accomodations for effective integration of a production EVA capability into the space station are contained. A description of the EVA systems for which the space station must provide the various interfaces and accomodations are provided. The discussion and analyses of the various space station areas in which the EVA interfaces are required and/or from which implications for EVA system design requirements are derived, are included. The rationale is provided for all EVAS mechanical, fluid, electrical, communications, and data system interfaces as well as exterior and interior requirements necessary to facilitate EVA operations. Results of the studies supporting these discussions are presented in the appendix. B.G.

N87-22762# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

DEVELOPING A VOICE-CONTROLLED, COMPUTER-GENERATED DISPLAY TO ASSIST SPACE STATION ASTRONAUTS DURING MAINTENANCE ACTIVITY M.S. Thesis

PAUL J. PABICH Dec. 1986 240 p
(AD-A178997; AFIT/GSO/ENG/86D-1) Avail: NTIS HC A11/MF A01 CSCL 22B

This thesis illustrated a planning strategy for a voice-controlled, computer-generated maintenance display which would be used by astronauts when completing maintenance activity outside the proposed U.S. space station. After justifying the usefulness of a proposed systems engineering approach, five main objectives were provided: (1) the vertical stanchion of the Manipulator Foot Restraint would provide an adequate base for the display so it could be moved to and from the worksite; (2) liquid crystal display technology should be used; (3) for voice-controlled operations, the best type of recognition unit to use would be one where the unit understands only one speaker at a time and only one word at a time; (4) experimental data suggest that a hierarchical scheme should be used for the menu format; (5) use of text, audio, graphics, and color for the proposed display. Only text and graphics were recommended for use. A proposed display format was presented showing the placement of the menu, text and graphics using some known data about how the human brain processes information. GRA

N87-24102*# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Hearing, Bioacoustics, and Biomechanics.

GUIDELINES FOR NOISE AND VIBRATION LEVELS FOR THE SPACE STATION

Jun. 1987 39 p
(Contract NASA ORDER L-76724-B)
(NASA-CR-178310; NAS 1.26:178310) Avail: NTIS HC A03/MF A01 CSCL 20A

Human habitability noise and vibration guidelines for the Space Station are presented. These were developed by a working group of experts established by the Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) of the National Research Council's Commission on Behavioral and Social Science and Education. Noise exposure limits are suggested that will permit adequate speech communication, sleep, and hearing safety. Vibration exposure limits are suggested which will provide adequate comfort and permit adequate task performance. These are provided for guidance only for setting criteria. The exact criteria will depend on Space Station design and duty cycles. Author

14

GROWTH

Includes descriptions of scenarios, analyses and system technology requirements for the evolutionary growth of the Space Station system.

A87-38754* Management and Technical Services Co., Houston, Tex.

CONCEPTS FOR THE EVOLUTION OF THE SPACE STATION PROGRAM

ROGER B. MICHAUD, LADONNA J. MILLER (GE Management and Technical Services Co., Houston, TX), and GARY R. PRIMEAUX (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 561-570. refs
(SAE PAPER 860972)

An evaluation is made of innovative but pragmatic waste management, interior and exterior orbital module construction, Space Shuttle docking, orbital repair operation, and EVA techniques applicable to the NASA Space Station program over the course of its evolution. Accounts are given of the Space Shuttle's middeck extender module, an on-orbit module assembly technique employing 'Pringles' stack-transportable conformal panels, a flexible Shuttle/Space Station docking tunnel, an 'expandable dome' for transfer of objects into the Space Station, and a Space Station dual-hatch system. For EVA operations, pressurized bubbles with articulating manipulator arms and EVA hard suits incorporating maneuvering, life support and propulsion capabilities, as well as an EVA gas propulsion system, are proposed. A Space Station ultrasound cleaning system is also discussed. O.C.

A87-40353*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ADVANCED TECHNOLOGY FOR THE SPACE STATION

MARK B. NOLAN and DENNIS A. STONE (NASA, Johnson Space Center, Houston, TX) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 24-32.

The goals and objectives of the Space Station Advanced Development Program are discussed. Data from tests and experiments in the areas of attitude control and stabilization, communications and tracking, data management systems, man systems, mechanisms, power systems, structures, thermal systems, and EVA are examined. The approaches used to implement these programs and for data transfer are described. The plans for the development of the Space Station are presented. I.F.

N87-20340*# Bionetics Corp., Hampton, Va.

AN ADVANCED TECHNOLOGY SPACE STATION FOR THE YEAR 2025, STUDY AND CONCEPTS Contractor Report, May-Nov. 1986

M. J. QUEIJO, A. J. BUTTERFIELD, W. F. CUDDIHY, C. B. KING, and P. A. GARN Mar. 1987 191 p
(Contract NAS1-18267)
(NASA-CR-178208; NAS 1.26:178208) Avail: NTIS HC A09/MF A01 CSCL 22B

A survey was made of potential space station missions that might exist in the 2020 to 2030 time period. Also, a brief study of the current state-of-the-art of the major subsystems was undertaken, and trends in technologies that could impact the subsystems were reviewed. The results of the survey and study were then used to arrive at a conceptual design of a space station for the year 2025. Factors addressed in the conceptual design included requirements for artificial gravity, synergies between subsystems, and the use of robotics. Suggestions are made relative to more in-depth studies concerning the conceptual design and alternative configurations. Author

N87-23674*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPECULATIONS ON FUTURE OPPORTUNITIES TO EVOLVE BRAYTON POWERPLANTS ABOARD THE SPACE STATION

ROBERT E. ENGLISH 1987 29 p Presented at the 4th Symposium on Space Nuclear Power Systems, Albuquerque, N. Mex., 12-16 Jan. 1987; sponsored by Sandia National Labs.
(NASA-TM-89863; E-3530; NAS 1.15:89863) Avail: NTIS HC A03/MF A01 CSCL 10B

The Space Station provides a unique, low-risk environment in which to evolve new capabilities. In this way, the Space Station will grow in capacity, in its range of capabilities, and its economy of operation as a laboratory and as a center for space operations. Although both Rankine and Brayton cycles, two concepts for solar dynamic power generation, now compete to power the station, this paper confines its attention to the Brayton cycle using a mixture of He and Xe as its working fluid. Such a Brayton powerplant to supply the station's increasing demands for both electric power and heat has the potential to gradually evolve higher and higher performance by exploiting already-evolved materials (ASTAR-811C and molten-Li heat storage), its peak cycle temperature rising ultimately to 1500 K. Adapting the station to exploit long tethers (200 to 300 km long) could yield increases in payloads to LEO, to GEO, and to distant destinations in the solar system. Such tethering of the Space Station would not only require additional power for electric propulsion but also would so increase nuclear safety that nuclear powerplants might provide this power. From an 8000-kWt SP-100 reactor, thermoelectric power generation could produce 300 kWe, or adapted solar-Brayton cycle, 2400 to 2800 kWe. Author

N87-26841 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Systems Group.

THE EVOLUTION OF A SERVICEABLE EURECA

J. WEYANDT, H. P. RICHARZ, H. WARTENBERG, and L. KERSTEIN *In its* Research and Development. Technical-Scientific Publications 1986 p 195-206 1986 Presented at the 37th IAF-Congress, Innsbruck, Austria, 6-10 Oct. 1986 Previously announced in IAA as A87-15825
(MBB-UR-E-923/86; IAF-86-38) Avail: Issuing Activity

The evolution of the ground-based platform EURECA is depicted. The platform design and the adaptation to scientific missions and servicing operations are explained. The cost-effective utilization of the different platform types using new operational concepts is analyzed in parametric life cycle cost calculations for different payloads and mission scenarios. By covering of broad spectrum of user requirements, EURECA could capture a wider payload market. ESA

15

MISSIONS, TETHERS, AND PLATFORMS

Includes descriptions and requirements of missions and tethers onboard the Space Station and platforms that are either co-orbiting with the Space Station, in polar orbit, or in geosynchronous orbit and which are part of the Space Station system.

A87-32192*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HOLLOW CATHODE-BASED PLASMA CONTACTOR EXPERIMENTS FOR ELECTRODYNAMIC TETHER

MICHAEL J. PATTERSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 46 p. refs
(AIAA PAPER 87-0572)

The role plasma contactors play in effective electrodynamic tether operation is discussed. Hollow cathodes and hollow cathode-based plasma sources have been identified as leading candidates for the electrodynamic tether plasma contactor. Present experimental efforts to evaluate the suitability of these devices as plasma contactors are reviewed. This research includes the definition of preliminary plasma contactor designs, and the characterization of their operation as electron collectors from a simulated space plasma. The discovery of an 'ignited mode' regime of high contactor efficiency and low impedance is discussed, as well as is the application of recent models of the plasma coupling process to contactor operation. Results indicate that ampere-level electron currents can be exchanged between hollow cathode-based plasma contactors and a dilute plasma in this regime. A discussion of design considerations for plasma contactors is given which includes expressions defining the total mass flow rate and power requirements of plasma contactors operating in both the cathodic and anodic regimes, and correlation of this to the tether current. Finally, future ground and spaceflight experiments are proposed to resolve critical issues of plasma contactor operation. Author

A87-32236*# Johns Hopkins Univ., Laurel, Md.

CONFIGURATION TRADEOFFS FOR THE SPACE INFRARED TELESCOPE FACILITY POINTING CONTROL SYSTEM

A. J. PUE, K. STROHBEHN, and J. W. HUNT (Johns Hopkins University, Laurel, MD) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 73-82) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 209-215. NASA-sponsored research. Previously cited in issue 22, p. 3241, Accession no. A85-45885. refs

A87-32298

GEOSTATIONARY PLATFORMS - AN INTERNATIONAL PERSPECTIVE

ROBERT E. BERRY, NEIL J. BARBERIS, and PAUL A. MONTE (Ford Aerospace and Communications Corp., Western Development Laboratories Div., Palo Alto, CA) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 79-82.

Past studies of geostationary platforms have focused on its communications capabilities and have tended to develop this resource within the context of national and/or regional services. The economic viability of these platforms are measured within this synoptic scale through comparison with implementation schemes utilizing individual satellites. The authors contend, however, that the primary characteristics of a geostationary platform (namely, aggregation of services, economies of scale, and connectivity) demand that the platforms be developed and their viability measured within the context of a 'global communications' architecture. This architecture would comprise sets of platforms, each providing regional services and east/west connectivity among the three designated International Telecommunications Union (ITU) regions. This global concept can be achieved only if the operational interfaces between the platform sets are compatible. This compatibility can only be assured if the various platform studies are coordinated and a test bed platform is developed to validate these operational concepts and interfaces. Author

A87-32521

PRELIMINARY RESULTS OF CHARGE-2 TETHERED PAYLOAD EXPERIMENT

S. SASAKI, K. I. OYAMA, N. KAWASHIMA, T. OBAYASHI (Tokyo, University, Japan), K. HIRAO (Tokai University, Hiratsuka, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1835-1840.

Data from the CHARGE-2 tethered payload experiment are analyzed. The CHARGE-2 experiment, which was to inject an electron beam using a tethered mother-daughter payload system, was conducted on December 14, 1985 at White Sands Missile Range, NM. The payload instruments launched by the Black Brant and Terrier rockets, and the beam firing sequence are described.

It is determined that the average wire length reached was 426 m during 289 sec and the average speed during deployment was 1.47 m/sec; a correlation between the reaction control system firings and an increase in velocity was observed. The data reveal that charging was lower at higher altitudes when the beam current was less than 80 mA. Consideration is given to tether current with and without beam emission, beam trajectory, VLF wave enhancement with tether deployment, and wave generation by beam emissions. I.F.

A87-32533

ON THE PAYLOAD-TETHER TECHNOLOGY PROVIDING THE MICROGRAVITY CIRCUMSTANCES IN THE PROXIMITY OF THE SPACE STATION

SHOICHI YOSHIMURA and TATSUO YAMANAKA (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1921-1926. refs

Preliminary results on a study of payload-tether technology, in which an upward or downward deployable experimental payload is connected to the Space Station through a tether to attenuate the propagation of G-jitters during microgavity experiments, are presented. Simplified models of the tether/payload system demonstrate the frequency separation of the natural frequency of the system from the G-jitter spectrum, and indicate a 260-m permissible tether length for 500-km altitude circular orbit. Numerical simulations of the system dynamics without control are performed using a Space Station/tether/payload system model. It is suggested that additional consideration is necessary on the definition of the residual force in the payload, directly related to the G level. R.R.

A87-32536

ADVANCED TECHNOLOGY EXPERIMENT ONBOARD SPACE PLATFORM

KYOICHI KURIKI (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1951-1956.

The experiments tentatively planned to be performed aboard the Space Flyer Unit (SFU), a small free-flying space platform which is designed as an observatory carrying a telescope and a test bed for advanced technology and to be carried and deployed by the STS, are discussed. The following experiments, which are the candidates for the SFU, are described in detail: (1) the Two-Dimensional Array Deployment, (2) the High-Voltage Solar Array Experiment, (3) the Electric Propulsion Experiment, (4) the Microwave Power Transmission Experiment, (5) the Space Experiment with Particle Accelerators, (6) the Tether Subsatellite Experiment, (7) the Satellite Retrieval Experiment, (8) the Biology Experiment, (9) the Solidification and Crystal Growth Experiment, and (10) the High-Precision Pointing System for Infrared Telescope. Multiple configuration diagrams are presented. I.S.

A87-32538

DESIGN OF A POLAR PLATFORM WITH AN EARTH OBSERVATION PAYLOAD

F. E. SAWDON (British Aerospace, PLC, Space and Communications Div., Bristol, England) and D. W. S. LODGE (British National Space Centre, London, England) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1965-1969.

The European polar platform (EPP) segment of the ESA Columbus contribution to the Space Station is to have an indefinite on-orbit lifetime, achieved by manned servicing to changeout experiments, failed components and replenish consumables. Meteorology, oceanography, atmospheric monitoring, and land and littoral monitoring applications are foreseen for the platform, which will have an initial payload of 2.4 tons and have a 5 kW power supply. The nominal orbit will be sun-synchronous at 850 km altitude with an average 102 min period. Three modules, propulsion, utilities and payload, will be launched by the Shuttle. The modules will be assembled with the RMS aided by EVA astronauts performing final checkouts. The procedures and equipment for scheduled 2 yr Shuttle servicing missions are delineated, along with data transmission system features and the use of orbital replacement units for payload and utilities changeouts. M.S.K.

A87-33687#

SOME APPROXIMATIONS FOR THE DYNAMICS OF SPACECRAFT TETHERS

A. H. VON FLOTOW (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 314-321. USAF-sponsored research. refs

(AIAA PAPER 87-0821)

The dynamics of typical tethered spacecraft systems are studied in an expository approximate way, with spectral separation invoked to reduce the dynamics of the system to a relatively fast vibrational motion which is decoupled from and superimposed upon the slow roll/yaw librations of the system. The fast tether vibrations occur with respect to a slowly varying quasi-equilibrium. The equilibrium shape of the tether is shown to be slightly nonlinear, and the small perturbations from this equilibrium are given by a system of linear partial differential equations. Nondimensional parameter groups which govern the character of the fast tether vibration are specified. R.R.

A87-34871

SPACE STATION - OPPORTUNITIES FOR THE LIFE SCIENCES

M. H. HARRISON (RAF, Institute of Aviation Medicine, Farnborough, England) British Interplanetary Society, Journal (Space Chronicle) (ISSN 0007-084X), vol. 40, March 1987, p. 117-124. refs

Opportunities for bioprocessing, basic biological research and space medicine offered by the Space Station are examined. Space offers two conditions which are duplicated on earth only with great difficulty; microgravity and high vacuum. Microgravity permits enhanced control of temperature and concentration gradients and particle distributions in fluids and containerless processing. Several likely candidates for electrophoresis processing in space are identified, noting that the greatest obstacle to realizing the new industry is commercial doubts as to its viability. Areas of cell and animal physiology, radiation biology, and exobiology that would benefit from Space Station research are considered. Finally, necessary space medicine research, by NASA and ESA, in medicine, toxicology, human factors, psychology, and adaptation to microgravity in support of the Space Station program are explored. M.S.K.

A87-35222* Arizona Univ., Tucson.

ASTROMETRIC TELESCOPE OF TEN MICROARCSECOND ACCURACY ON THE SPACE STATION

E. H. LEVY, R. S. MCMILLAN (Arizona, University, Tucson), G. D. GATEWOOD, and J. W. STEIN (Allegheny Observatory, Pittsburgh, PA) IN: Advanced technology optical telescopes III; Proceedings of the Meeting, Tucson, AZ, Mar. 3-6, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 181-187. refs

(Contract NAG2-348)

The Astrometric Telescope Facility (ATF) will be operated in the NASA Space Station in the 1990s, furnishing long term, highly accurate relative astrometry of nearby stars in order to detect gravitational perturbations by companion stars with masses as small as that of Neptune. An accuracy of 10 microarcsec is required; this is 100 times better than ground observatory performance. In the Gatewood et al. (1980) astrometric technique used, the relative positions of star images in the telescope focal plane are indicated by the relative phases of the modulations of star brightnesses introduced by translating a Ronchi ruling across the focal plane at uniform speed. Space Station vibration damping, fine guiding accuracy, optical configuration, Ronchi ruling metric accuracy, and the choice of detectors, are discussed. O.C.

A87-36531* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DESIGN CONSIDERATIONS FOR LONG-LIVED GLASS MIRRORS FOR SPACE

FRANK L. BOUQUET, CARL R. MAAG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and PHILIP M. HEGGEN (Energy General, Menlo Park, CA) IN: Materials and optics for solar energy conversion and advanced lighting technology; Proceedings of the Meeting, San Diego, CA, Aug. 19-21, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 94-101. DOE-sponsored research. refs

Large mirrors intended for long-term operation in orbital space will have to retain high reflectance in the presence of contamination or destruction by high-energy particles, meteorites, and orbiting debris. These conditions require the use of low-energy outer surfaces that resist the buildup of contamination, the use of small mirror segments that restrict local damage and facilitate replacement, and the use of surface coatings that minimize the effects of atomic oxygen and/or charge buildup. The present recommendations are based on experience accumulated with terrestrial solar-concentrator mirror materials. O.C.

A87-37785

CODED MASK TELESCOPES FOR X-RAY ASTRONOMY

G. K. SKINNER and T. J. PONMAN (Birmingham, University, England) British Interplanetary Society, Journal (Space Science) (ISSN 0007-084X), vol. 40, April 1987, p. 169-172. refs

The principle of the coded mask techniques are discussed together with the methods of image reconstruction. The coded mask telescopes built at the University of Birmingham, including the SL 1501 coded mask X-ray telescope flown on the Skylark rocket and the Coded Mask Imaging Spectrometer (COMIS) projected for the Soviet space station Mir, are described. A diagram of a coded mask telescope and some designs for coded masks are included. I.S.

A87-38002#

STATUS OF THE RITA - EXPERIMENT ON EURECA

H. BASSNER, H.-P. BERG, W. BIRNER (MBB-ERNO Raumfahrttechnik GmbH, Ottobrunn, West Germany), C. BARTOLI, and A. TRIPPI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987. 6 p.
(AIAA PAPER 87-0988)

The radiofrequency ion thruster assembly (RITA) is currently built as a flight experiment which shall be flown on the European retrievable carrier (Eureca I). This test flight shall verify the operational use of this electric propulsion system in space by demonstration of operation, lifetime and reliability. For this purpose the RITA experiment has been adapted to meet the specific constraints imposed by the Eureca I spacecraft and by the Space Shuttle as the launcher; xenon gas will be used as the propellant and the experiment will be operated automatically by means of a dedicated on-board microcomputer system. According to the delay in launches by the Space Shuttle the launch date has been postponed from March 1988 to 1991/92. Therefore the total Eureca program has been extended, which also influenced the RITA time schedule. Author

A87-38567* Howard Univ., Washington, D. C.

TETHERS IN SPACE; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, ARLINGTON, VA, SEPT. 17-19, 1986

PETER M. BAINUM, ED. (Howard University, Washington, DC), IVAN BEKEY, ED. (NASA, Office of Space Flight, Washington, DC), LUCIANO GUERRIERO, ED. (CNR, Rome, Italy), and PAUL A. PENZO, ED. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Conference sponsored by NASA, CNR, AIAA, AAS, et al. San Diego, CA, Univelt, Inc. , 1987, 765 p. For individual items see A87-38568 to A87-38574.

A collection of papers on the applications of tethers in space is presented. Tether flight experiments of the past, in planning stages, and in the future are examined. Tether dynamics and the applications and technical aspects of electrodynamic tethers are addressed. The use of tethers on the Space Station and applications in the Space Station era are considered. Individual tether technology issues, including tether materials and instrumentation for atmospheric measurements are discussed. C.D.

A87-38568* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

A SURVEY OF TETHER APPLICATIONS TO PLANETARY EXPLORATION

PAUL A. PENZO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 71-88. refs
(AAS PAPER 86-206)

Concepts for the use of tethers in various hypothetical astronomical research missions are discussed. Tethers used to study the atmospheres of Venus and Mars and the magnetosphere of Jupiter are examined, and possible orbiting tether systems at the moon and Mars are shown and described. A tether method for collecting a sample from Comet Halley is addressed along with a system for hovering near a comet. A multiple sample return system for asteroids is described, and a heliocentric Alfven engine concept to study the solar wind is discussed. C.D.

A87-38570

TETHERED SATELLITE PROGRAM CONTROL STRATEGY

CARL S. BODLEY and HOWARD A. FLANDERS (Martin Marietta Corp., Denver, CO) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 295-299.
(AAS PAPER 86-221)

This presentation covers the essential equations for the control of the libration of a tethered system during the retrieval phase. Based on the assumption of ideal tension control and range and range rate feedback, theoretical regions of stability are determined for constant in-plane libration angles. These results are obtained by transforming the relative motion perturbation equations to a set of second order equations with constant coefficients. This resulting set of equations is analyzed in the frequency domain to generate stable retrieval angle limits as a function of the range and range rate error feedback gains. These stability boundaries are verified with nonlinear time domain simulations. The equations for shaping deployment and retrieval profiles are also presented. Author

A87-38571* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

TETHER POWER SUPPLIES EXPLOITING THE CHARACTERISTICS OF SPACE

CHRISTOPHER PURVIS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 407-438. refs
(AAS PAPER 86-227)

The author presents an alternative approach to the conception and design of future space power systems, with a particular emphasis on the use of tethers in space. Two concepts are presented in support of this design approach. The first concept is a secondary power system for large-scale energy storage and release, and the second is a prime power system for large-scale production of electrical power from the solar flux. In each case basic equations are presented, discussed, and point design values are given as examples. The technology of superconduction is found to be greatly enhancing for the first concept, and the development of very light weight solar reflectors is considered enabling for the second. Author

A87-38573

TETHER SYSTEM AND CONTROLLED GRAVITY

LUIGI G. NAPOLITANO, RODOLFO MONTI, and GENNARO RUSSO (Napoli, Universita, Naples, Italy) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 589-605. CNR-supported research. refs
(AAS PAPER 86-240)

The use of tethers to create an environment of controlled microgravity in space is examined. The study of the effects of gravity on a generic parameter X using controlled microgravity is considered. Scientific and commercial applications of a controllable g-field are briefly addressed, and the use of tether systems as microgravity platforms is discussed, indicating the types of experiments that could be performed on such platforms. C.D.

A87-38574* National Aeronautics and Space Administration, Washington, D.C.

TECHNOLOGY AND APPLICATIONS - CONVERGENCE TO A TETHER CAPABILITY

JOHN L. ANDERSON (NASA, Office of Aeronautics and Space Technology, Washington, DC) IN: Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 635-643. refs
(AAS PAPER 86-244)

In this paper, a convergence of interest from many potential tether applications is synthesized into one application that could be satisfied by a tethered satellite capability. This application is the use of a tethered research satellite deployed downward from the Shuttle Orbiter to gather scientific and engineering/technology data about the outer atmosphere from about 90 to 130 km. The atmospheric and aerothermodynamic information needed about this region of the atmosphere is identified, and the specific applications of that information, the tether capability, and the technology needed to gather the data are described. C.D.

A87-38756* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LIFE SCIENCE RESEARCH FACILITY MATERIALS MANAGEMENT REQUIREMENTS AND CONCEPTS

CATHERINE C. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 579-585.
(SAE PAPER 860974)

The Advanced Programs Office at NASA Ames Research Center has defined hypothetical experiments for a 90-day mission on Space Station to allow analysis of the materials necessary to conduct the experiments and to assess the impact on waste processing of recyclable materials and storage requirements of samples to be returned to earth for analysis as well as of nonrecyclable materials. The materials include the specimens themselves, the food, water, and gases necessary to maintain them, the expendables necessary to conduct the experiments, and the metabolic products of the specimens. This study defines the volumes, flow rates, and states of these materials. Process concepts for materials handling will include a cage cleaner, trash compactor, biological stabilizer, and various recycling devices. Author

A87-38757* Boeing Aerospace Co., Seattle, Wash.

PLANT AND ANIMAL ACCOMMODATION FOR SPACE STATION LABORATORY

RICHARD L. OLSON, EDITH A. GUSTAN, and LOWELL F. WILEY (Boeing Aerospace Co., Seattle, WA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 587-601. refs
(Contract NAS8-35471)
(SAE PAPER 860975)

An extended study has been conducted with the goals of defining and analyzing relevant parameters and significant tradeoffs for the accommodation of nonhuman research aboard the NASA Space Station, as well as conducting tradeoff analyses for orbital reconfiguring or reoutfitting of the laboratory facility and developing laboratory designs and program plans. The two items exerting the greatest influence on nonhuman life sciences research were identified as the centrifuge and the specimen environmental control and life support system; both should be installed on the ground rather than in orbit. O.C.

A87-39183

THE TETHERED SATELLITE SYSTEM AS A NEW REMOTE SENSING PLATFORM

S. VETRELLA and A. MOCCIA (Napoli, Universita, Naples, Italy) International Journal of Remote Sensing (ISSN 0143-1161), vol. 8, March 1987, p. 369-383. Research supported by the Ministero della Pubblica Istruzione and CNR. refs

The characteristics and development of the Tethered Satellite (TS), which is to be a space platform that allows operation at different low altitudes, are described. Two experimental flights are proposed for the TS; the first mission involves deploying the tether 20 km upwards, and in the second mission the TS is to be deployed downwards to 100 km from the Shuttle. The attitude stability rates of the TS for along-track stereoscopic observations using linear arrays are analyzed. It is determined that an attitude stability rate of 10 to the -6th deg/sec is required for automatic correlation along epipolar planes during the proposed Mapsat mission and a rate of 0.00001 deg/sec is needed for the Stereosat mission. I.F.

A87-40319*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

EXPERIMENTATION IN PLANETARY GEOLOGY

MARK J. CINTALA (NASA, Johnson Space Center, Houston, TX) Reviews of Geophysics (ISSN 8755-1209), vol. 25, March 1987, p. 304-308. refs

Laboratory simulations of geological processes on the terrestrial planets are described, summarizing results published during the period 1983-1986. Included are studies of wind-driven processes on Mars and Venus (using the special wind-tunnel facilities at NASA Ames); simulations of shock-induced loss of volatiles from solids; equation-of-state determinations; impact experiments simulating cratering, spallation, regolith formation, and disruption; fluid-flow simulations of channel formation on Mars; and dust studies. The use of the microgravity environment of the Space Station for planetary-geology experiments is briefly considered. T.K.

A87-40510#

ELECTRODYNAMIC TETHER PROPULSION - POTENTIAL USES AND OPEN ISSUES

JOSEPH A. CARROLL, JOHN C. OLDSON (Energy Science Laboratories, Inc., San Diego, CA), and WILLIAM B. THOMPSON (California, University, San Diego) International Electric Propulsion Conference, 19th, Colorado Springs, CO, May 11-13, 1987, Paper. 4 p.

A current flowing through a long straight wire or conducting tether in earth orbit (and returning externally through the ionosphere) will react against the earth's magnetic field and can provide propulsion - without expending reaction mass. If such an electrodynamic tether is practical, it may be simpler and more efficient - in use of power and mass - than any other form of electric propulsion. This paper reviews this concept and potential applications, and discusses some key unresolved issues. Author

A87-40858#

ORBITAL MODIFICATIONS USING FORCED TETHER-LENGTH VARIATIONS

MANUEL MARTINEZ-SANCHEZ and SARAH A. GAVIT (MIT, Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 233-241. refs

It is shown that once-per-orbit modulations of the length of an orbiting tether can be used to modify the eccentricity, energy, and line of apsides orientation of its center of mass while maintaining a constant angular momentum and orbital parameter. Appropriate length variation laws are developed and the effects are quantified and interpreted. Several applications are discussed, including modifications to the orbit of a Space Station, reduction by 30 percent of the Delta-V to launch a satellite to 12 h orbit, and the relocation of the apogee for observation satellites. Author

A87-40859*# Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.

A THREE-MASS TETHERED SYSTEM FOR MICRO-G/VARIABLE-G APPLICATIONS

ENRICO C. LORENZINI (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 97-105) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 242-249. Previously cited in issue 23, p. 3425, Accession no. A86-47413. refs
(Contract NAS8-36606)

A87-41430

A POLAR PLATFORM FOR THE REMOTE SENSING NEEDS OF ECOLOGY AND AGRICULTURE - A VIEW FROM THE U.K.

P. J. CURRAN and S. E. PLUMMER (Sheffield, University, England) International Journal of Remote Sensing (ISSN 0143-1161), vol. 8, April 1987, p. 555-567. refs
(Contract NERC-P80/G6/16)

The main characteristics of the proposed polar-orbiting remote sensing satellites to be implemented in the Space Station program are described. The potential benefits of the polar platforms to remote sensing are discussed. The remote sensing needs of UK scientists in the areas of ecology and agriculture are examined. I.F.

A87-42585* Massachusetts Inst. of Tech., Cambridge.

THE RADIATION IMPEDANCE OF AN ELECTRODYNAMIC TETHER WITH END CONNECTORS

DANIEL E. HASTINGS and J. WANG (MIT, Cambridge, MA) Geophysical Research Letters (ISSN 0094-8276), vol. 14, May 1987, p. 519-522. refs
(Contract NAG3-695)

Electrodynamic tethers are wires deployed across the earth's geomagnetic field through which a current is flowing. The radiation impedance of a tether with end connectors carrying an ac current is computed from classical antenna theory. This simulates the use of a tether on a space structure. It is shown that the current flow pattern at the tether connector is critical to determining the overall radiation impedance. If the tether makes direct electrical contact with the ionosphere then radiation impedances of the order of several thousand Ohms can be expected. If the only electrical contact is through the end connectors then the impedance is only a few Ohms for a dc current rising to several tens of Ohms for an ac current with frequencies in the whistler range. Author

A87-43154* National Aeronautics and Space Administration, Washington, D.C.

THE EVOLUTION OF THE GEOSTATIONARY PLATFORM CONCEPT

BURTON I. EDELSON, ROBERT R. LOVELL, and C. LOUIS CUCCIA (NASA, Office of Space Science and Applications, Washington, DC) IEEE Journal on Selected Areas in Communications (ISSN 0733-8716), vol. SAC-5, May 1987, p. 601-614. refs

The paper will review the conceptual development over the last decade of the use of very large spacecraft, i.e., 'platforms', in geostationary orbit. Geostationary platforms were originally conceived as an efficient means of increasing the capacity at a point in the geostationary orbital arc. Also, geostationary platforms have been suggested for mounting very large antennas as will be required for mobile communications, or high power sources as will be required for broadcast services to small terminals. More recently these 'large satellite' platforms were also envisioned as including earth observation and other science payloads. The advent of the Space Station, which can provide a staging base for platform assembly and test in space at low earth orbit prior to launch to geostationary earth orbit, will introduce a new dimension to practical platform design. This paper describes the evolution of concepts for geostationary platforms over the last decade based on both communications and science user scenarios developed worldwide. Author

A87-43165* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN ADVANCED GEOSTATIONARY COMMUNICATIONS PLATFORM

THADDEUS A. HAWKES, WILLIAM CLOPP (RCA, Astro-Space Div., Princeton, NJ), and JACK LEKAN (NASA, Lewis Research Center, Cleveland, OH) IEEE Journal on Selected Areas in Communications (ISSN 0733-8716), vol. SAC-5, May 1987, p. 749-758. refs

A large geostationary communications platform can offer many attractive possibilities for providing lower cost communications. The platform payload concept described in this paper attempts to exploit these possibilities. The use of a combination of spot and wide-area coverage beams accommodates users in both high- and low-density population areas, and provides a good degree of frequency reuse. A standard channel bandwidth, used for most traffic, facilitates interconnectivity among C-, Ku-, and Ka-band users who may all access the platform. Adoption of a 36-MHz channel bandwidth leads to transmission rates that would be easily handled by low-cost terminals providing direct customer premises service. This also lends itself well to a solution using a large number of solid-state power amplifiers operating in all three frequency bands and sharing a common, redundant, conditioned power supply. Author

A87-43354#

A PROPOSAL FOR SPACE TETHER DAMAGE INDICATION, LOCATION, AND EVALUATION - THE REPAIR MONKEY MODULE

WARREN G. GRECZYN AIAA Student Journal (ISSN 0001-1460), vol. 25, Spring 1987, p. 12-14, 32.

A proposed tether damage location and evaluation technique that uses the Repair Monkey Module (RMM) is described. The theory of conducting tether power generation is discussed. The operation of the RMM to detect and evaluate tether damage is examined. Consideration is given to the configuration, continuous belt drive design, and the video cameras and internal lights (for damage evaluation) of the RMM; diagrams of the RMM configuration and subsystems are provided. I.F.

A87-44176* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

REMOTE SENSING; PROCEEDINGS OF THE MEETING, ORLANDO, FL, APR. 3, 4, 1986

ROBERT T. MENZIES, ED. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 644), 1986, 115 p. For individual items see A87-44177 to A87-44187.
(SPIE-644)

Advances in optical technology for remote sensing are discussed in reviews and reports of recent experimental investigations. Topics examined include industrial applications, laser diagnostics for combustion research, laser remote sensing for ranging and altimetry, and imaging systems for terrestrial remote sensing from space. Consideration is given to LIF in forensic diagnostics, time-resolved laser-induced-breakdown spectrometry for rapid analysis of alloys, CARS in practical combustion environments, airborne inertial surveying using laser tracking and profiling techniques, earth-resources instrumentation for the EOS polar platform of the Space Station, and the SAR for EOS. T.K.

A87-44184* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

EARTH RESOURCES INSTRUMENTATION FOR THE SPACE STATION POLAR PLATFORM

MARTIN J. DONOHOE (NASA, Goddard Space Flight Center, Greenbelt, MD) and DEBORAH VANE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 76-81. NOAA-sponsored research. refs

The spacecraft and payloads of the Space Station Polar Platform program are described in a brief overview. Present plans call for one platform in a descending morning-equator-crossing orbit at 824 km and two or three platforms in ascending afternoon-crossing orbits at 542-824 km. The components of the NASA Earth Observing System (EOS) and NOAA payloads are listed in tables and briefly characterized, and data-distribution requirements and the mission development schedule are discussed. A drawing of the platform, a graph showing the spectral coverage of the EOS instruments, and a glossary of acronyms are provided. T.K.

A87-44185* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

CONCEPTUAL DESIGN OF THE HIGH-RESOLUTION IMAGING SPECTROMETER (HIRIS) FOR EOS

MARK HERRING (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 82-85. refs

The design concept and practical realization of HIRIS, the imaging spectrometer being developed for the Space Station Earth Observation System (EOS) on the basis of the Shuttle Imaging Spectrometer Experiment (SISEX), are discussed. Nominal operating parameters for HIRIS include altitude 705 km, GIFOV 30 m, swath 48.4 km, spectral sampling interval 10 nm, spectral coverage 400-2450 nm, cross-track pointing +20/-20 deg, down-track pointing +60/-30 deg, and raw data rate (at 8 bits/pixel) 621 Mb/s. The f/1.9 optical configuration for HIRIS is shown in a drawing, and consideration is given to technological challenges being encountered in modifying the SISEX focal-plane detectors, data-reduction procedures, and cooling system to meet the HIRIS requirements. T.K.

A87-44186* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

PRELIMINARY SYSTEM CONCEPTS FOR MODIS - A MODERATE RESOLUTION IMAGING SPECTROMETER FOR EOS

W. L. BARNES, H. OSTROW, and V. V. SALOMONSON (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 86-93. refs

Plans are underway at NASA Goddard to develop a moderate-resolution (0.5-1.0-km) imaging spectrometer with 104 spectral bands in the range from 0.4 to 14.2 microns for use as a NASA facility aboard the Space Station Earth Observation System. Science requirements call for the system to image the earth's surface every 2 d for a period of 10 yr, using two electrooptic sensors. MODIS-T (tilt) has 64 10-nm-wide channels in the 400-1000-nm range. The system has 5-cm-diameter optics, scans + or - 45 deg, and can be pointed + or - 60 deg along track. Calculated S/N is in excess of 800:1 near 400 nm. MODIS-N (nadir) scans + or - 45 deg about nadir with 12 500-m- and 28 1000-m-resolution channels, including two polarization channels and 14 thermal-IR channels. With 20-cm-diameter optics the calculated S/N of the majority of the reflected solar bands is over 1000:1. NETD values for the thermal bands are on the order of 0.1-0.2 K at 300 K. Combined MODIS-T and MODIS-N data rates are 8.3 Mb/s in daylight and 1.5 Mb/s at night, resulting in a total of 360 Gb/d. T.K.

A87-44187* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THE EARTH OBSERVING SYSTEM (EOS) SYNTHETIC APERTURE RADAR (SAR)

JOBEA CIMINO and DAN HELD (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 94-107. refs

The evolution of the Spaceborne Imaging Radar (SIR) has led to a multipolarization, multifrequency SAR with variable imaging geometry which will be ready for flight on the Space Station Earth Observing System (EOS). Nominally, this SAR will be a three-frequency (L-, C-, and X-band) system with quad polarization available for the L and C bands. It will be capable of acquiring multiincidence-angle data using electronic beam steering, and other imaging geometries by mechanically pitching, yawing, and rolling the antenna. The capabilities of the EOS SAR, particularly acquisition of cross-polarized and high-incidence-angle data, depend on the altitude of the platform on which the SAR flies and improve significantly at lower altitudes. The EOS SAR will provide a unique new data set and will play a key role in understanding the earth's global processes, alone and synergistically with other EOS instruments. Author

A87-44533* Perkin-Elmer Corp., Danbury, Conn.

OPTICAL ARRAYS FOR FUTURE ASTRONOMICAL TELESCOPES IN SPACE

ALAN N. BUNNER (Perkin-Elmer Corp., Space Science Div., Danbury, CT) IN: Infrared, adaptive, and synthetic aperture optical systems; Proceedings of the Meetings, Arlington, VA, Apr. 8, 1985 and Orlando, FL, Apr. 1, 2, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 180-188. refs
(Contract NAS8-36105)

NASA's Marshall Space Flight Center is currently evaluating several advanced optical space telescope concepts for the achievement of both higher sensitivity and greater angular resolution than the Hubble Space Telescope; their designs encompass one- and two-dimensional coherent arrays of mirrors in both focal and afocal configurations. Attention is given to those arrays that appear capable of fabrication and orbital deployment by the year 2005, and to the tradeoff involved between synthetic aperture concepts that furnish high angular resolution and those that yield sensitivity for faint, extended source imaging. O.C.

A87-50447#

THE MISSION FUNCTION CONTROL FOR DEPLOYMENT AND RETRIEVAL OF SUBSATELLITE

HIRONORI FUJII and SHINTARO ISHIJIMA (Tokyo Metropolitan Institute of Technology, Japan) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 395-399. refs
(AIAA PAPER 87-2326)

This paper presents a new control algorithm applied to the problem of deployment and retrieval of a subsatellite connected through a tether to the main body. From control theory an idea of the 'mission function' is introduced, which is an index used to describe the concept of the mission. The mission function is defined to be positive definite and to be zero when the given mission is completed. The deployment and retrieval is thus controlled to decrease the mission function. The control law is totally different from the control laws that have been presented in the literature; linearity and simple open-loop control are not assumed. In addition the present theory can be applied equally to both the deployment and the retrieval cases. A simplified model is used to clarify the fundaments of the problem, only in-plane motion is treated and neither flexibility nor air drag is included. Results of numerical simulation show an excellent controlled behavior. Author

A87-50750*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AN ASTROMETRIC FACILITY FOR PLANETARY DETECTION ON THE SPACE STATION

KENJI NISHIOKA, JEFFREY D. SCARGLE, and JOHN J. GIVENS (NASA, Ames Research Center, Moffett Field, CA) International Symposium on Optical and Optoelectronic Applied Science Engineering, 4th, The Hague, Netherlands, Mar. 28-Apr. 3, 1987, Paper. 13 p. refs

The preliminary system definition study for an Astrometric Telescope Facility (ATF) designed for the Space Station IOC is discussed, and a strawman system is designed which is found to meet the requirements for extrasolar planetary systems search and study. The strawman facility design, with a prime-focus 1.25-m aperture telescope and an f ratio of 13, was selected to minimize random and systematic errors. A basic operations approach is identified, including the approach to launch, initial on-orbit assembly and checkout, normal operations, and the response to anomolous conditions or failures. The preliminary system is designed to be fail-safe and single-fault tolerant. Mission analysis indicates that the basic viewing required for planetary detection can be accomplished in about 2/3 of the total viewing time. R.R.

A87-52450* Naples Univ. (Italy).

THE TETHERED SATELLITE SYSTEM FOR LOW DENSITY AEROTHERMODYNAMICS STUDIES

GIOVANNI M. CARLOMAGNO, LUIGI DE LUCA (Napoli, Universita, Naples, Italy), P. M. SIEMERS, III, and GEORGE M. WOOD, JR. (NASA, Langley Research Center, Hampton, VA) Unione Italiana de Termofluidodinamica, Congresso Nazionale sulla Trasmissione del Calore, 4th, Genoa, Italy, June 5-7, 1986, Paper. 15 p. refs
(Contract CNR-PSN-84-048; CNR-PSN-85-082)

The feasibility of the operation of the Tethered Satellite System (TSS) as a continuous open wind tunnel for low-density aerothermodynamic studies (applicable to the design of hypersonic space vehicles including STARFAC, AOTV, and ERV) is considered. The Shuttle Continuous Open Wind Tunnel (SCOWT) program, for the study of the energy and momentum transfer between the tethered satellite and its environmental medium during the TSS/2 mission, is described. Instrumentation and TSS design requirements to meet SCOWT objectives are also considered. SCOWT will provide information on the gasdynamic processes occurring downstream of the bow wave standing in front of the TS, the chemistry and physics of the upper atmosphere related to satellite aerothermodynamics, and TSS's overall experimental envelope of operation. R.R.

A87-53002* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SPACE STATION GAS-GRAIN SIMULATION FACILITY - APPLICATION TO EXOBIOLOGY

C. P. MCKAY, C. R. STOKER (NASA, Ames Research Center, Moffett Field CA), J. MORRIS, G. CONLEY (Colorado, University, Boulder), and D. SCHWARTZ (SETI Institute, Los Altos, CA) (COSPAR, Plenary Meeting, 26th, Topical Meeting and Workshop 4 on Life Sciences and Space Research XXII/2/, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 12, 1986, p. 195-206. refs

The technical issues involved in performing experiments on the behavior and properties of aerosols in a microgravity environment provided by the Space Station are reviewed. The displacement of a particle resulting from g-jitter for ballistic, Knudsen, and Stokes flow regimes is examined in detail, and the radiation, acoustic, electrostatic, and electromagnetic mechanisms for the control of this motion are described. The simulation of organic haze production on Titan has been selected as an example experiment for detailed study. The purpose of this experiment was to simulate the photolysis of methane and the subsequent formation of the organic haze particles in the Titan upper atmosphere. B.J.

A87-53149

OPERATIONAL INSTRUMENTS ON THE SPACE STATION-POLAR PLATFORMS - CONTRIBUTIONS BY NOAA AND THE INTERNATIONAL COMMUNITY

BRUCE H. NEEDHAM (NOAA, National Environmental Satellite, Data and Information Service, Washington, DC) IN: IGARSS '87 - International Geoscience and Remote Sensing Symposium, Ann Arbor, MI, May 18-21, 1987, Digest. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 387-392.

In the mid-1990's, the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) will combine efforts to launch the Space Station along with two orbiting Polar Platforms. The National Oceanic and Atmospheric Administration (NOAA) will be utilizing the NASA and ESA Polar Platforms to carry its operational instruments for environmental remote sensing as a logical follow on to the current series which ends with the NOAA-K, L, M satellites. This paper will describe the operational instruments that NOAA proposes to fly on the two Polar Platforms, and other international contributions that are under consideration. Author

A87-54197

INFRA-RED ASTRONOMY AFTER IRAS

JOHN K. DAVIES (Royal Observatory, Edinburgh, Scotland) Space (ISSN 0267-954X), vol. 3, July-Aug. 1987, p. 20-24.

A number of performed and proposed space astronomy missions are discussed. The IRAS mission which mapped almost the entire sky at wavelengths of 12, 25, 60, and 100 microns detecting 250,000 IR sources and the Spacelab-2 IR telescope which observed about 90 percent of the sky per orbit are examined. Consideration is given to the design and objectives of the proposed ESA Cosmic Background Explorer mission and the IR Space Observatory, the U.S. Space IR Telescope Facility, and the Soviet Aelita mission. The development of the Far IR Space Telescope, which is to be an 8-m antenna for submm astronomy, and the Large Deployable Reflector, a 12-15-m orbiting telescope for the 2 micron to 1 mm range, is being studied. I.F.

A87-54198

DEVELOPING SPACE STATION. II - POWER, RENDEZVOUS, DOCKING AND REMOTE SENSING ARE IMPORTANT ELEMENTS OF THE SPACE STATION

ROY HATHAWAY Space (ISSN 0267-954X), vol. 3, July-Aug. 1987, p. 35-37, 48.

Some systems and applications for the proposed Space Station are considered. The use of GaAs cells in the solar power systems for the Space Station is examined; the fabrication, characteristics, and costs of GaAs solar cells are described. Rendezvous and docking capabilities are required for the Space Station to function as a polar platform; a monopulse tracking radar is being evaluated as the docking system for the Station. The benefits the Space Station, operating as a polar platform, can provide to remote sensing, in particular meteorology, environmental research, and solar terrestrial physics, are discussed. I.F.

N87-20359# MATRA Espace, Toulouse (France). Dept. of Satellite Engineering.

QUALIFICATION OF THE FAINT OBJECT CAMERA

PATRICE AMADIEU *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 13 p Jul. 1986
Avail: NTIS HC A12/MF A01

The Faint Object Camera (FOC) is presently integrated as one of the five Scientific Instruments in the NASA Space Telescope (ST) which after an extensive integration and tests campaign should be launched in 1986. The Space Telescope is an observatory of 13 metres long, 4.3 metres diameter and 11,000 kilogrammes which will be placed by the Space Shuttle in a 500 kms circular orbit. The Faint Object Camera installed at the ST focal plane is a complex instrument with a total weight of 320 kgs and overall dimensions 1 x 1 x 2.2 metres. A Structural/Thermal Model (STM) and flight model of the FOC have been built. The FOC/STM was subjected to an extensive test program with for the mechanical part, sine and random vibrations, acoustic noise and modal test.

On the FOC/PFM, acoustic noise only was applied for workmanship verification. With the FOC integrated now in the Space Telescope, and considering the specimen overall dimensions, limited mechanical testing will be applied at ST level which will consist of modal survey and acoustic noise. Then at the end of the test program, the overall assembly will be shipped to Kenndey Space Center and launched. Author

N87-20621# European Space Agency, Paris (France).
PROCEEDINGS OF THE EUROPEAN SYMPOSIUM ON POLAR PLATFORM OPPORTUNITIES AND INSTRUMENTATION FOR REMOTE-SENSING (ESPOIR)
E. J. ROLFE, ed. and B. BATTRICK, ed. Nov. 1986 127 p
Symposium held in Avignon, France, 16-18 Jun. 1986
(ESA-SP-266; ISSN-0379-6566; ETN-87-99434) Avail: NTIS HC A07/MF A01

European activities in preparing the Columbus polar platforms; United States cooperation with Europe; atmosphere, land, ocean/ice, and solid Earth missions; and platform instruments, calibrating, data management, orbit configuration, and servicing were discussed.

ESA

N87-20622# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
THE EARTH OBSERVATION ACTIVITIES OF THE EUROPEAN SPACE AGENCY AND THE USE OF THE POLAR PLATFORM OF THE INTERNATIONAL SPACE STATION
B. PFEIFFER *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 7-10 Nov. 1986
Avail: NTIS HC A07/MF A01

The Meteosat, ERS-1, and Earthnet programs are reviewed. The long term follow-on programs are outlined. Space infrastructure elements of ESA and their use for Earth observation are described. User requirements and ESA policy for a polar Earth observations platform are discussed. ESA

N87-20625# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
WORKING GROUP ON EARTH OBSERVATION REQUIREMENTS FOR THE POLAR ORBITING PLATFORM ELEMENTS OF THE INTERNATIONAL SPACE STATION (THE POPE WORKING GROUP)
N. DEVILLIERS *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 29-33 Nov. 1986
Avail: NTIS HC A07/MF A01

A polar platform specification for Earth observations was defined. It features 2 platforms in coordinated Sun-synchronous orbits at an altitude of 800 km (morning and afternoon orbits); a multidisciplinary payload divided between the platforms growing from 2.4 tons initially (per platform) through 3.6 tons at the first servicing to a mature amount of 4.8 tons per platform at the second service point; and servicing every 2 to 3 yr, adding new payloads and upgrading payloads. The power requirements grow from 2 to 2.5 KW initially, through 4 KW, to 6 KW. The data rates of up to several hundred megabits per second are compatible with: direct downlinking, and the proposed European Data Relay Satellite System; the lower data rates generated globally are compatible with on-board recording techniques. ESA

N87-20631# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
COOPERATION OF THE INTERNATIONAL SPACE STATION PARTNERS IN THE PREPARATION OF THE USE OF SPACE STATION ELEMENTS FOR EARTH OBSERVATION (PLATFORM AND PAYLOAD ASPECTS)
B. PFEIFFER *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 65-67 Nov. 1986
Avail: NTIS HC A07/MF A01

Space station elements and launch/services means for polar missions are discussed. European interests are identified. Items for further study and coordination between space station partners are suggested. Potential polar platform instruments, and their providers, are listed. ESA

N87-20634# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
LAND PANEL REPORT
J. BODECHTEL and F. LANZL *In* ESA Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 79-83 Nov. 1986
Avail: NTIS HC A07/MF A01

International Space Station polar platform sensor configurations and missions are suggested. The platforms should maintain the capability for operational land remote sensing using optical sensors; improve the capability of optical sensors in terms of radiometric and spatial resolution, coverage, stereoscopic capability, etc.; improve experimental capabilities for allweather remote sensing of land with microwave sensors, to provide an operational capability similar to that of optical sensors; optimize the integration of microwave and optical data; set up demonstration programs in renewable resources, achieve operational status in the 1990s; and promote fundamental research activities. ESA

N87-20641*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN ASTROMETRIC FACILITY FOR PLANETARY DETECTION ON THE SPACE STATION
KENJI NISHIOKA, JEFFREY D. SCARGLE, and JOHN J. GIVENS Apr. 1987 16 p Presented at the 4th International Symposium on Optical and Optoelectronic Applied Science Engineering, The Hague, Netherlands, 28 Mar. - 3 Apr. 1987
(NASA-TM-89436; A-87133; NAS 1.15:89436) Avail: NTIS HC A02/MF A01 CSCL 03A

An Astrometric Telescope Facility (ATF) for planetary detection is being studied as a potential space station initial operating capability payload. The primary science objective of this mission is the detection and study of planetary systems around other stars. In addition, the facility will be capable of other astrometric measurements such as stellar motions of other galaxies and highly precise direct measurement of stellar distance within the Milky Way Galaxy. The results of a recently completed ATF preliminary systems definition study are summarized. Results of this study indicate that the preliminary concept for the facility is fully capable of meeting the science objective without the development of any new technologies. A simple straightforward operations approach was developed for the ATF. A real-time facility control is not normally required, but does maintain a near real-time ground monitoring capability for the facility and science data stream on a full-time basis. Facility observational sequences are normally loaded once a week. In addition, the preliminary system is designed to be fail-safe and single-fault tolerant. Routine interactions by the space station crew with the ATF will not be necessary, but onboard controls are provided for crew override as required for emergencies and maintenance. Author

N87-21973# Joint Publications Research Service, Arlington, Va.
STATUS OF ORBITAL ASTRONOMY PROJECTS
YE. NELEPO *In its* USSR Report: Space (JPRS-USP-87-001) p 11-12 19 Feb. 1987 Transl. into ENGLISH from Trud (Moscow, USSR), 25 Oct. 1986 p 3
Avail: NTIS HC A11/MF A01

Plans for orbiting spacecraft with telescopes for radio, gamma-ray, and X-ray astronomy are reported. One radio astronomy project involves an interferometric system of interactive ground and space telescopes. An X-ray observatory is being developed for the orbiting station Mir. Granat, an orbiting observatory, will measure hot plasmas in clusters of galaxies, X-ray pulsars, and regions surrounding black holes. B.G.

N87-22457*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
PROBLEMS IN MERGING EARTH SENSING SATELLITE DATA SETS
PAUL H. SMITH and MICHAEL J. GOLDBERG Mar. 1987 15 p
(NASA-TM-87820; REPT-87B0275; NAS 1.15:87820) Avail: NTIS HC A02/MF A01 CSCL 12B

Satellite remote sensing systems provide a tremendous source of data flow to the Earth science community. These systems provide scientists with data of types and on a scale previously unattainable. Looking forward to the capabilities of Space Station and the Earth Observing System (EOS), the full realization of the potential of satellite remote sensing will be handicapped by inadequate information systems. There is a growing emphasis in Earth science research to ask questions which are multidisciplinary in nature and global in scale. Many of these research projects emphasize the interactions of the land surface, the atmosphere, and the oceans through various physical mechanisms. Conducting this research requires large and complex data sets and teams of multidisciplinary scientists, often working at remote locations. A review of the problems of merging these large volumes of data into spatially referenced and manageable data sets is presented. Author

N87-22506*# Alabama Univ., Huntsville. College of Science.
INVESTIGATION OF BEAM-PLASMA INTERACTIONS Final Report
RICHARD C. OLSEN May 1987 29 p
(Contract NAG3-620)
(NASA-CR-180579; NAS 1.26:180579) Avail: NTIS HC A03/MF A01 CSCL 20I

Data from the SCATHA satellite was analyzed to solve the problems of establishing electrical contact between a satellite and the ambient plasma. The original focus of the work was the electron gun experiments conducted near the geosynchronous orbit, which resulted in observations which bore a startling similarity to observations of the SEPAC experiments on SPACELAB 1. The study has evolved to include the ion gun experiments on SCATHA, a modest laboratory effort in hollow cathode performance, and preparation for flight experiments pertinent to tether technology. These areas are addressed separately. Author

N87-22509*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
INVESTIGATION OF PLASMA CONTACTORS FOR USE WITH ORBITING WIRES Semiannual Report, 1 Jul. - 31 Dec. 1986
ROBERT D. ESTES Jun. 1987 20 p
(Contract NAG8-126)
(NASA-CR-180922; NAS 1.26:180922; SAR-2) Avail: NTIS HC A02/MF A01 CSCL 20I

The effort to determine the size and shape of the hollow cathode cloud emitted from an orbiting system was continued. In addition, the results obtained for the ionospheric wave impedance of a tethered system was applied to the experiments under consideration. The recent plasma chamber experimental results reported by Urrutia and Stenzel are still being considered. The problem is being studied as to how the ionospheric plasma's global response to the moving disturbance presented by the electrodynamic tethered satellite system affects the system's ability to function as a power generator or thruster. Author

N87-22570*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ASTRONOMIC TELESCOPE FACILITY: PRELIMINARY SYSTEMS DEFINITION STUDY REPORT. VOLUME 2: TECHNICAL DESCRIPTION
CHARLIE SOBECK, ed. May 1987 400 p
(NASA-TM-89429-VOL-2; A-87172; NAS 1.15:89429-VOL-2)
Avail: NTIS HC A17/MF A01 CSCL 03A

The Astrometric Telescope Facility (AFT) is to be an earth-orbiting facility designed specifically to measure the change in relative position of stars. The primary science investigation for the facility will be the search for planets and planetary systems outside the solar system. In addition the facility will support astrophysics investigations dealing with the location or motions of stars. The science objective and facility capabilities for astrophysics investigations are discussed. B.G.

N87-22571*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ASTROMETRIC TELESCOPE FACILITY PRELIMINARY SYSTEMS DEFINITION STUDY. VOLUME 1: EXECUTIVE SUMMARY
CHARLIE SOBECK Mar. 1987 61 p
(NASA-TM-89429-VOL-1; A-87113; NAS 1.15:89429-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 03A

The Astrometric Telescope Facility (ATF) is a spaceborne observatory proposed for use on the Space Station (SS) as an Initial Operating Capability (IOC) payload. The primary objective of the ATF will be the search for extrasolar planetary systems and a detailed investigation of any discovered systems. In addition, it will have the capability of conducting other astrophysics investigations; e.g., measuring precise distances and motions of stars within our galaxy. The purposes of the study were to: (1) define mission and system requirements; (2) define a strawman system concept for the facility at the Prephase A level; (3) define the need for additional trade studies or technology development; and (4) estimate program cost for the strawman concept. It has been assumed for the study that the ATF will be a SS payload, will use a SS-provided Coarse Pointing System (CPS), will meet SS constraints, and will make maximum use of existing flight qualified designs or designs to be qualified by the SS program for general SS use. R.J.F.

N87-22756# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
OPTIMAL SHUTTLE ALTITUDE CHANGES USING TETHERS M.S. Thesis
ROBERT R. FISHER Dec. 1986 64 p
(AD-A179205; AFIT/GA/AA/86D-5) Avail: NTIS HC A04/MF A01 CSCL 22A

The use of tethers in space has been proposed for many years. While much work has been done recently on the use of tethers for towed satellites from the Space Shuttle, little has been done to determine the possible benefits of using tethers as propulsive devices to supplement or replace rocket engines for boost from Low Earth Orbit. Orbit insertion parameters such as velocity and final altitude for the space shuttle are limited by operational constraints on the possible delta V that can be supplied from the engines. The possibility of increasing the performance of the shuttle exists in using an inter-connecting tether to serve as a momentum transfer device between the External Tank and the Shuttle. This added momentum would widen the possible orbit options presently available by boosting the shuttle to a higher orbit. This project derives the equations of motion for a three-body connected dynamical system to include the Shuttle, the external tank, and the cable in orbit around a spherical Earth. Due to current material limitations the tether length will be limited to 100 kilometers. The possible envelope of orbital changes is investigated. GRA

N87-24256*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
HIGH ENERGY GAMMA RAY ASTRONOMY
CARL E. FICHTEL *In its* Essays in Space Science p 227-274 Jun. 1987
Avail: NTIS HC A18/MF A01 CSCL 03A

High energy gamma ray astronomy has evolved with the space age. Nonexistent twenty-five years ago, there is now a general sketch of the gamma ray sky which should develop into a detailed picture with the results expected to be forthcoming over the next decade. The galactic plane is the dominant feature of the gamma ray sky, the longitude and latitude distribution being generally correlated with galactic structural features including the spiral arms. Two molecular clouds were already seen. Two of the three strongest gamma ray sources are pulsars. The highly variable X-ray source Cygnus X-3 was seen at one time, but not another in the 100 MeV region, and it was also observed at very high energies. Beyond the Milky Way Galaxy, there is seen a diffuse radiation, whose origin remains uncertain, as well as at least one quasar, 3C 273. Looking to the future, the satellite opportunities for high energy gamma ray astronomy in the near term are the GAMMA-I planned to be launched in late 1987 and the Gamma Ray Observatory, scheduled for launch in 1990. The Gamma Ray Observatory will carry a total of four instruments covering the entire energy range from 30,000 eV to 3 x 10 to the 10th eV with over an order of magnitude increase in sensitivity relative to previous satellite instruments. Author

N87-25033# Open Univ., Oxford (England).
IDEAS FOR EDUCATIONAL PHYSICS EXPERIMENTS IN SPACE
DAVID A. BLACKBURN *In* ESA Proceedings of the GIREP Conference 1986. Cosmos: An Educational Challenge p 43-46 Nov. 1986
Avail: NTIS HC A20/MF A01

Spaceborne demonstrations dealing with centers of mass, convection, conservation of angular and linear momentum, and quantitative experiments concerning fluid motion, Keplerian orbits, and human body movements are suggested. Possible student groups (from astronauts to the general public) are indicated. ESA

N87-25351# Army Military Personnel Center, Alexandria, Va.
THERMAL AND DYNAMICAL EFFECTS ON ELECTRODYNAMIC SPACE TETHERS Final Report
JOHN S. PRALL, JR. 8 May 1987 139 p
(AD-A180276) Avail: NTIS HC A07/MF A01 CSCL 10A

Electrodynamic tethers are essentially long conducting wires which, when deployed from an orbiting satellite, can generate power by converting orbital mechanical energy into electrical energy for use on the satellite. An analytical and numerical analysis was carried out on the operation of an electrodynamic tether system used for power generation and/or thrusting in a space environment. Three problems were examined. First, the efficiency of an uninsulated tether of prescribed design, as determined by the magnitude of current leakage along its length due to positive ion capture and secondary electron emissions, was compared to that of a perfectly insulated tether of identical design. Second, the effects on system efficiency of variations in the design parameters of the tether and the orbit in which it operates were examined by means of a numerical analysis of the thermal balance of the system. Third, the effects which the mode of operation of the tether has on the classical elements of the orbit in which it operates were examined through a numerical analysis. GRA

N87-25506 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Systems Group.
THE RADARSAT MODULAR OPTO-ELECTRONIC MULTISPECTRAL SCANNER (R-MOMS): A POTENTIAL CANDIDATE FOR THE POLAR ORBITING PLATFORM (POP) ALSO
D. MEISSNER and H. L. WERSTIUK 1986 11 p Presented at the 37th International Astronautical Federation Congress on Space: New Opportunities for All People, Innsbruck, Austria, 4-11 Oct. 1986 Previously announced in IAA as A87-15855 Submitted for publication
(MBB-UR-873/86; IAF-86-81; ETN-87-99936) Avail: Issuing Activity

The design and performance characteristics of the Radarsat opto-electronic scanner (R-MOMS) are outlined, and its use on the Polar Orbiting Platform (POP) is proposed. The R-MOMS consists of 4 spectral channels with center wavelengths 0.485, 0.555, 0.650, and 0.825 microns, with 13,500 usable pixels. Strip width is 405 km, with a ground pixel size of 60, 30, 30, and 30 m for the 4 bands. For POP, an along-track stereo mode can be added. ESA

N87-25560# National Oceanic and Atmospheric Administration, Washington, D. C. Special Projects Div.
PLANNING FOR FUTURE OPERATIONAL SENSORS AND OTHER PRIORITIES
JAMES C. FISCHER, ed., WALTER PLANET, LARRY STOWE, and WILLIAM L. SMITH Jun. 1987 50 p
(NOAA-NESDIS-30) Avail: NTIS HC A03/MF A01

The study programs established by the National Environmental Satellite, Data, and Information Service (NESDIS) Office of Systems Development for polar orbiting and geostationary platform sensors are defined. The main thrust of the studies is to prepare an operational payload for the polar platform portion of the space station program. The Advanced Medium Resolution Infrared Radiometer (AMRIR) will be a replacement for the Advanced Very High Resolution Radiometer (AVHRR) and the High Resolution Infrared Radiometer Sounder (HIRS), now operational on the NOAA series of polar orbiters. The Global Ozone Monitoring Radiometer (GOMR) will replace the Solar Backscatter Ultraviolet (SBUV) on the polar platform as the operational ozone monitor. A series of geostationary environmental satellites, beginning with GOES-I, will offer improved image products and operate the first operational sounder from a geostationary satellite. Plans directed towards the development of other sensors are discussed and programs to support microwave science investigations are described. M.G.

N87-25767*# Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.
A METHOD OF VARIABLE SPACING FOR CONTROLLED PLANT GROWTH SYSTEMS IN SPACEFLIGHT AND TERRESTRIAL AGRICULTURE APPLICATIONS
J. KNOX Oct. 1986 20 p
(Contract NCC2-210)
(NASA-CR-177447; NAS 1.26:177447) Avail: NTIS HC A02/MF A01 CSCL 06K

A higher plant growth system for Controlled Ecological Life Support System (CELSS) applications is described. The system permits independent movement of individual plants during growth. Enclosed within variable geometry growth chambers, the system allocates only the volume required by the growing plants. This variable spacing system maintains isolation between root and shoot environments, providing individual control for optimal growth. The advantages of the system for hydroponic and aeroponic growth chambers are discussed. Two applications are presented: (1) the growth of soybeans in a space station common module, and (2) in a terrestrial city greenhouse. Author

N87-26083*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT, PHASE 2 Quarterly Report No. 9, 1 Apr. - 30 Jun. 1987
ENRICO C. LORENZINI Jul. 1987 56 p
(Contract NAS8-36606)
(NASA-CR-179149; NAS 1.26:179149) Avail: NTIS HC A04/MF A01 CSCL 22B

A control law was developed to control the elevator during short-distance maneuvers along the tether of a 4-mass tethered system. This control law (called retarded exponential or RE) was analyzed parametrically in order to assess which control parameters provide a good dynamic response and a smooth time history of the acceleration on board the elevator. The short-distance maneuver under investigation consists of a slow crawling of the elevator over the distance of 10 m that represents a typical maneuver for fine tuning the acceleration level on board the elevator. The contribution of aerodynamic and thermal perturbations upon acceleration levels was also evaluated and acceleration levels obtained when such pertubations are taken into account were compared to those obtained by neglecting the thermal and aerodynamic forces. In addition, the preparation of a tether simulation questionnaire is illustrated. Analytic solutions to be compared to numerical cases and simulator test cases are also discussed. Author

N87-26174*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
REVIEW OF LOW EARTH ORBITAL (LEO) FLIGHT EXPERIMENTS
L. LEGER, B. SANTOSMASON, J. VISENTINE, and J. KUMINECZ *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 1-10 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 22A

The atomic oxygen flux exposure experiments flown on Space Shuttle flights STS-5 and STS-8 are described along with the results of measurements made on hardware returned from the Solar Maximum repair mission (Space Shuttle flight 41-C). In general, these experiments have essentially provided for passive exposure of samples to oxygen fluences of approximately 1 to 3.5 x 10(20) atoms/sq cm. Atmospheric density is used to derive fluence and is dependent on solar activity, which has been on the decline side of the 11-year cycle. Thus, relatively low flight altitudes of less than 300 km were used to acquire these exposures. After exposure, the samples were analyzed using various methods ranging from mass loss to extensive scanning electron microscopy and surface analysis techniques. Results are summarized and implications for the space station are discussed. M.G.

N87-26188*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEUTRAL ATOMIC OXYGEN BEAM PRODUCED BY ION CHARGE EXCHANGE FOR LOW EARTH ORBITAL (LEO) SIMULATION
BRUCE BANKS, SHARON RUTLEDGE, MARKO BRDAR, CARL OLEN, and CURT STIDHAM (Cleveland State Univ., Ohio.) *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 127-134 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

A low energy neutral atomic oxygen beam system was designed and is currently being assembled at the Lewis Research Center. The system utilizes a 15 cm diameter Kaufman ion source to produce positive oxygen ions which are charge exchange neutralized to produce low energy (variable from 5 to 150 eV) oxygen atoms at a flux simulating real time low Earth orbital conditions. An electromagnet is used to direct only the singly charged oxygen ions from the ion source into the charge exchange cell. A retarding potential grid is used to slow down the oxygen ions to desired energies prior to their charge exchange. Cryogenically cooled diatomic oxygen gas in the charge exchange cell is then used to transfer charge to the oxygen ions to produce a neutral atomic oxygen beam. Remaining non-charge exchanged oxygen ions are then swept from the beam by electromagnetic or electrostatic deflection depending upon the desired experiment configuration. The resulting neutral oxygen beam of 5 to 10 cm in diameter impinges upon target materials within a sample holder fixture that can also provide for simultaneous heating and UV exposure during the atomic oxygen bombardment. Author

N87-26191*# Vanderbilt Univ., Nashville, Tenn. Dept. of Physics and Astronomy.
THE PRODUCTION OF LOW-ENERGY NEUTRAL OXYGEN BEAMS BY GRAZING-INCIDENCE NEUTRALIZATION Abstract Only
R. G. ALBRIDGE, R. F. HAGLUND, N. H. TOLK, and A. F. DAECH (Martin Marietta Aerospace, New Orleans, La.) *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 155 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

The Vanderbilt University neutral oxygen facility produces beams of low-energy neutral oxygen atoms by means of grazing-incidence collisions between ion beams and metal surfaces. Residual ions are reflected by applied electric fields. This method can utilize initial ion beams of either O(+) or O2(+) since a very large percentage of molecular oxygen ions are dissociated when they undergo grazing-incidence neutralization. The method of neutralization is applicable to low-energy beams and to all ions. Particular emphasis is on O and N2 beams for simulation of the low Earth orbit space environment. Since the beam is a pure O-neutral beam and since measurements of the interaction of the beam with solid surfaces are made spectroscopically, absolute reaction rates can be determined. The technique permits the beams to be used in conjunction with electron and photon irradiation for studies of synergistic effects. Comparisons of optical spectra of Kapton excited by 2.5-keV O, O(+), and O2(+) show significant differences. Optical spectra of Kapton excited by neutral oxygen beams of less than 1 keV have been recorded. Author

N87-26449*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRODYNAMIC TETHER
MICHAEL PATTERSON *In its* Space Photovoltaic Research and Technology 1986. High Efficiency, Space Environment and Array Technology p 343 Jun. 1987
Avail: NTIS HC A16/MF A01 CSCL 22B

Electrodynamic tethers hold promise for a variety of space applications. Electrodynamic tethers depend upon the interactions between a moving insulated conductor and the Earth's magnetic field. An electric field is generated along the tether as in a conductor moving in the magnetic field of a generator. If the circuit is closed to the ambient space plasma via a plasma gun or other equivalent device, a current is enabled to flow in the tether, and electric power is generated at the expense of orbital mechanical energy. The net effect is a decrease in the altitude of the orbiting tethered system. The situation can be reversed by driving current against the electric field via an external power supply such as a photovoltaic array. Author

N87-26967# Systems Science and Software, La Jolla, Calif.
DOCUMENTATION FOR THE SHADO PARTICLE WAKE ROUTINE Technical Report, Oct. 1986 - Jan. 1987
D. L. PETERKA and I. KATZ Jan. 1987 25 p
(Contract F19628-86-C-0056)
(AD-A181531; SSS-R-87-8495; AFGL-TR-87-0042; SR-5) Avail: NTIS HC A02/MF A01 CSCL 22B

This report documents the computational algorithms of the SHADO routine for computing the particle wake behind large spacecraft in low polar orbit. SHADO will replace the existing module for computing particle densities in the POLAR code and achieves a significant improvement in computational speed. GRA

N87-29085*# Ball Aerospace Systems Div., Boulder, Colo.
PHASE 3 STUDY OF SELECTED TETHER APPLICATIONS IN SPACE. VOLUME 1: EXECUTIVE SUMMARY Final Report
Dec. 1986 33 p
(Contract NAS8-36617)
(NASA-CR-179185; NAS 1.26:179185; DPD-665-VOL-1; DR-4-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 22B

A tethered launch assist from the Shuttle for payloads with up to 10,000 kg mass for the mission model and the tethering of a 15,000 kg science platform for the space station were addressed. Also encompassed was the design and cost analysis for a variable g device that could be placed on the tether and allow ultralow g or other types of experiments to be conducted. Numerous tether applications were examined and their theoretical feasibility and technology requirements were assessed. B.G.

N87-29591*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
INVESTIGATION OF PLASMA CONTACTORS FOR USE WITH ORBITING WIRES Final Report, 1 Jan. 1986 - 30 Jun. 1987
ROBERT D. ESTES, MARIO D. GROSSI, and ROBERT HOHLFELD Sep. 1987 106 p
(Contract NAG8-126)
(NASA-CR-181422; NAS 1.26:181422) Avail: NTIS HC A06/MF A01 CSCL 22B

The proposed Shuttle-based short tether experiments with hollow cathodes have the potential for providing important data that will not be obtained in long tether experiments. A critical property for hollow cathode effectiveness as a plasma contactor is the cross magnetic field conductivity of the emitted plasma. The different effects of hollow cathode cloud overlap in the cases of motion-driven and battery-driven operation are emphasized. The calculations presented on the size and shape of the hollow cathode cloud improve the qualitative picture of hollow cathodes in low Earth orbit and provide estimates of time constants for establishing the fully-expanded cloud. The magnetic boundary value problem calculations indicate the way in which the magnetic field will effect the shape of the cloud by resisting expansion in the direction perpendicular to the field. The large-scale interactions of the system were also considered. It was concluded that recent plasma chamber experiments by Stenzel and Urrutia do not model an electrodynamic tether well enough to apply the results to tethered system behavior. Orbiting short tether experiments on hollow cathodes will provide critical information on hollow cathode performance and the underlying physics that cannot be obtained any other way. Experiments should be conducted as soon as funding and a suitable space vehicle are available. B.G.

N87-29633*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Physics.

OXYGEN INTERACTION WITH SPACE-POWER MATERIALS Annual Report, 1 May 1986 - 30 Apr. 1987

T. G. ECK and R. W. HOFFMAN Oct. 1987 16 p
(Contract NAG3-696)
(NASA-CR-181396; NAS 1.26:181396) Avail: NTIS HC A02/MF A01 CSCL 07D

Data from the space shuttle flights have established that many materials experience relatively rapid degradation when exposed to the low Earth orbit ambient atmosphere, which is predominately atomic oxygen. While much was learned from samples flown on the shuttle, laboratory simulations of the shuttle environment are necessary for a detailed understanding of the various interactions which contribute to the observed degradations. These laboratory experiments are particularly important for predicting the deterioration to be expected for materials aboard orbiting power systems, which will be exposed for long periods of time and could have components operating at very high temperatures. By using a mass spectrometer to synchronously detect molecules emitted from the surface as a result of amplitude modulated oxygen ion bombardment, quantum yields were obtained as a function of ion energy. A technique was developed to obtain preliminary yield data by slowly scanning the mass setting of the mass spectrometer; measurements were extended down to zero modulation frequency; yield data was obtained for the insulating materials (Nomex, Kevlar, and Teflon) used in the construction of electrodynamic tethers; a heated sample holder was constructed to investigate the effect of sample temperature on quantum yields; and the instrumentation was developed to observe the mass spectrometer signal as a function of time during and following bombardment of the sample by a brief (approximately 1 millisecond) pulse of ions. Author

16

OPERATIONS SUPPORT

Includes descriptions of models, analyses and trade studies of maneuvers, performance, Logistics support, and EVA and/or IVA servicing requirements of systems such as the OMV and OTV, and experiments.

A87-32006

SPACE STATION EVA SIMULATION DEMONSTRATES ORBITAL ASSEMBLY

CRAIG COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 126, Jan. 26, 1987, p. 60, 61, 63, 65.

An experimental account is presented of a 3 hr work period in a neutral buoyancy tank being used by McDonnell Douglas Astronautics to study Space Station construction activities. The work period was devoted to examining connecting joints and nodes for truss structures. Safety and activity recording measures implemented for the session are described. Particular note is made of tasks which exacerbated hand fatigue, techniques discovered for facilely assembling utility trays, and methods for quick and precise beam alignment. The simulations provide data for responses to requests for proposals for Space Station projects. M.S.K.

A87-32474

SPACE LAUNCHER UPPER STAGES - DESIGN FOR MISSION VERSATILITY AND/OR ORBITAL OPERATION

R. G. REICHERT (Dornier System GmbH, Friedrichshafen, West Germany) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1463-1474.

Upper stage concepts for present and future space launchers are considered, with emphasis on the future achievement of mission versatility and economy. A modular design concept is discussed with allows adjustment of the propellant with respect to payload-mass and velocity requirements by selection of the appropriate number of tank-modules for the given mission. Tank-staging can be applied for extreme velocity-requirements, and orbital assembly and refueling techniques are discussed in conjunction with Space Station planning. Future possibilities for reusable OTVs are considered, with application to commercial, geostationary transportation. The economic advantages and facility requirements of a space-based stage operation are also discussed. R.R.

A87-32543

ON-ORBIT FLUID MANAGEMENT

RALPH N. EBERHARDT and DALE A. FESTER (Martin Marietta Corp., Denver, CO) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1995-2005. refs

The operational scenarios, technology status and design drivers for fluid management systems (FMS) for space applications are outlined. The systems are of concern for ground- and space-based vehicles, i.e., the former operating in and out of the atmosphere and the latter in LEO, GEO and/or beyond. The vehicles may be filled and launched, some to return, or may stay in space, such as is to happen with an Orbit Transfer Vehicle (OTV). Estimates are made of the total fuel requirements for the year 2000, and design and safety contraints for interfacing on-orbit hypergolic fuel systems with the Shuttle and Space Station are considered. The discussion centers on FMS operations with a resupply tanker, a Space Station depot and a user system such as the OTV. Attention is given to the options for selections of pressurization, venting, mass gaging and slosh and thermal control systems, and prototype systems under test are described. M.S.K.

A87-32612

SATELLITE SERVICING LOGISTICS

JOSEPH E. ABEL (Lockheed Missiles and Space Co., Inc., Huntsville, AL) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p.
(SAE PAPER 861723)

Current and anticipated satellite servicing logistics tasks in support of commercial, scientific, and military space based operations are addressed. Anticipated quantities of Orbital Replaceable Units and Orbital Replaceable Instruments on the Space Station and the projected multiple fleet of free flyers require that prompt attention to the supportability elements of on-orbit activities be an absolute and immediate priority. Anticipated costs to sustain orbital maintenance, servicing, and support of future free flyers and the Space Station leads to a conclusion that optimum support with reduced costs can best be achieved by standardization and centralization of support facilities. The logistics support elements described herein provide a scenario to achieve the supportability goals and reduce the overall satellite servicing costs. A preliminary cost analysis as part of this text confirms the need for a consolidated support program. Author

A87-32634* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

DESIGN AND DEVELOPMENT OF A SPACE STATION PROXIMITY OPERATIONS RESEARCH AND DEVELOPMENT MOCKUP

RICHARD F. HAINES (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p. refs
(SAE PAPER 861785)

Proximity operations (Prox-Ops) on-orbit refers to all activities taking place within one km of the Space Station. Designing a Prox-Ops control station calls for a comprehensive systems approach which takes into account structural constraints, orbital dynamics including approach/departure flight paths, myriad human factors and other topics. This paper describes a reconfigurable full-scale mock-up of a Prox-Ops station constructed at Ames incorporating an array of windows (with dynamic star field, target vehicle(s), and head-up symbology), head-down perspective display of manned and unmanned vehicles, voice- actuated 'electronic checklist', computer-generated voice system, expert system (to help diagnose subsystem malfunctions), and other displays and controls. The facility is used for demonstrations of selected Prox-Ops approach scenarios, human factors research (work-load assessment, determining external vision envelope requirements, head-down and head-up symbology design, voice synthesis and recognition research, etc.) and development of engineering design guidelines for future module interiors. Author

A87-32644

HUBBLE SPACE TELESCOPE SATELLITE SERVICING

W. E. JONES (Lockheed Missiles and Space Co., Inc., Huntsville, AL) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 14 p.
(SAE PAPER 861796)

The Hubble Space Telescope (HST) is the first satellite designed from the outset to accommodate servicing in space. Astronauts will have access to and be able to replace scientific instruments, guidance sensors, batteries, solar panels, computers, reaction wheels, etc., all configured as orbital replacement units (ORU). The HST outer shell has been fitted with 225 ft of handrails and 31 foot restraint receptacles. ORU fasteners were designed to permit facile disconnection and connection by astronauts wearing bulky spacesuits. Servicing is to be on regular 3 yr intervals, with retrieval and release from the Orbiter bay to take place at the 320 n. mi. operational orbit of the HST. The projected retrieval, link-up, repair and release procedures, hierarchical priority scheduling approach, and space support equipment to be carried on the Orbiter are explored. M.S.K.

A87-32667* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ROLE OF THE MANNED MANEUVERING UNIT FOR THE SPACE STATION

C. E. WHITSETT (NASA, Johnson Space Center, Houston, TX) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 18 p. refs
(SAE PAPER 861834)

The performance specifications to be realized in the Manned Maneuvering Unit (MMU) for Space Station operations will be the culmination of design efforts which began during the Gemini project. The types of MMUs which have been built and tested over the past two decades are described, including handheld, jet shoe, and initial rigid backpack configurations. Efforts to enhance the control laws and human factors aspects of the Skylab MMU to meet long-duration, flexible use Space Station requirements are summarized, noting the successes and deficiencies with the Shuttle MMU. The design requirements which must be met to allow the Space Station MMU to be used to perform rescue, transportation, inspection, assembly, contingency, and programmatic missions are explored. M.S.K.

A87-32733* Ball Aerospace Systems Div., Boulder, Colo.

RENDEZVOUS AND DOCKING TRACKER

ART J. RAY, SUSAN E. ROSS, and DOUGLAS R. DEMING (Ball Corp., Aerospace Systems Div., Boulder, CO) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 109-118. NASA-supported research.
(AAS PAPER 86-014)

A conceptual solid-state rendezvous and docking tracker (RDT) has been devised for generating range and attitude data for a docking vehicle relative to a target vehicle. Emphasis is placed on the approach of the Orbiter to a link with the Space Station. Three laser illuminators ring the optical axis of the lens a directed toward retroreflectors on the target vehicle. Each retroreflector is equipped with a bandpass filter for a designated illumination frequency. Data are collected sequentially over a 20 deg field of view as the range closes to 100-1000 m. A fourth ranging retroreflector 0.3 m from center is employed during close-in maneuvers. The system provides tracking data on motions with 6 deg of freedom, and furnishes 500 msec updates (to be enhanced to 100 msec) to the operator at a computer console. M.S.K.

A87-32743* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

USE OF THE ORBITAL MANEUVERING VEHICLE (OMV) FOR PLACEMENT AND RETRIEVAL OF SPACECRAFT AND PLATFORMS

WILLIAM C. SNODDY, WILLIAM E. GALLOWAY, and ARCHIE C. YOUNG (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 303-319.
(AAS PAPER 86-041)

This paper describes the Orbital Maneuvering Vehicle (OMV) and its intended role as a key element of NASA's space infrastructure. Status, plans, and operational modes are summarized. Typical mission scenarios supporting the servicing of spacecraft and platforms from both the Shuttle and the Space Station are described. Particular emphasis is placed on the orbital mechanics associated with the placement and retrieval of spacecraft and platforms. For example, the optimum placement of a Space Station co-orbiting spacecraft in order to maximize the time interval during which it can be retrieved by a Space Station based OMV is shown as a function of the ballistic coefficient of the spacecraft. Author

A87-32744* Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

AEROASSIST FLIGHT EXPERIMENT GUIDANCE, NAVIGATION AND CONTROL

TIMOTHY J. BRAND (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and ALBERT G. ENGEL IN: Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 . San Diego, CA, Univelt, Inc., 1986, p. 321-334. NASA-supported research. refs
(AAS PAPER 86-042)

The Aeroassist Flight Experiment scheduled for the early 1990's will demonstrate the use of a low L/D lifting brake using aerodynamic drag to return a spacecraft from a high energy to a low earth orbit. The experimental vehicle will be deployed and retrieved by the Shuttle Orbiter. This paper reviews some of the challenges, problems, and solutions encountered to date during guidance system development, with emphasis on technology advances which will benefit an operational Orbit Transfer Vehicle (OTV). Key factors to be discussed include guidance alternatives, aerodynamic modeling, navigation requirements, the impact of atmospheric uncertainties, and flight profile alternatives considered during initial planning. Author

A87-36362
THE SERVICE CONCEPT
IAN PARKER Space (ISSN 0267-954X), vol. 3, Mar.-Apr. 1987, p. 33, 35.

The SERVICE (space entry/reentry vehicle in commercial environments) concept is described. The main component of the system is a space recovery vehicle (SRV) which houses a self-contained laboratory or processing facility. The SRV, which can be utilized for the study of genetic engineering, adhesives, composites, and alloys, can be modified to user's requirements and can be flown on various launchers. The dimensions and design of the capsule are discussed. The use of the SRV as an escape capsule for manned space vehicles and for returning cargos from the Space Station to earth is proposed. I.F.

A87-37297*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION COMMUNICATIONS AND TRACKING SYSTEM
REINHOLD H. DIETZ (NASA, Johnson Space Center, Houston, TX) IEEE, Proceedings (ISSN 0018-9219), vol. 75, March 1987, p. 371-382.

A comprehensive description of the existing Space Station communications and tracking system requirements, architecture, and design concepts is provided. Areas which will require innovative solutions to provide cost-effective flight systems are emphasized. Among these are the space-to-space links, the differential global positioning system for determining relative position with free-flying vehicles, multitarget radar, packet/isochronous signal processing, and laser docking systems. In addition, the importance of advanced development, tests, and analyses is summarized. Author

A87-38755* Operations Research, Inc., Silver Spring, Md.
SERVICING OF USER PAYLOAD EQUIPMENT IN THE SPACE STATION PRESSURIZED ENVIRONMENT
JOEL LEVY, RUTH WHITMAN (ORI, Inc., Silver Spring, MD), THOMAS A. LAVIGNA, and JOHN E. OBERRIGHT (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 571-578.
(SAE PAPER 860973)

NASA Space Station servicing support facilities will include both pressurized and unpressurized work areas. While the latter will allow astronauts operating in EVAs or aided by robots to accomplish Orbital Replacement Unit (ORU) and instrument changes, tests, assembly, refueling, and repairs, the former will furnish astronauts engaged in work requiring intravehicular activities (IVAs) the ability to enter through an airlock into a module in which they can more carefully service ORUs. Baseline IVA accommodations encompass (1) a staging/assembly area for ORUs brought in from satellites, orbital platforms or attached payloads, (2) a work station for monitoring and control of the external Servicing Bay facility, and (3) a large, laminar flow workbench which would provide highly controlled conditions, as well as (4) a 'glovebox' for delicate servicing and (5) an assortment of hand tools and test equipment. O.C.

A87-38767
SPACE STATION EVA SYSTEMS TRADE-OFF MODEL
MAURICE A. CARSON (Eagle Engineering, Inc., Houston, TX), LARRY PRICE (McDonnell Douglas Astronautics Co., Saint Louis, MO), and BRUCE JAGOW (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 691-709.
(SAE PAPER 860990)

A procedure has been developed to predict program costs for conducting extravehicular activity from Space Station. Space Transportation System EMU historical data has been used as a basis for performing the development and production phases. Complexity and risk factors are used to compare costs for various configuration options. Operations costs utilize ground, launch, and on-orbit penalty factors derived from operations analysis and EVA hardware configuration and performance data. Scar costs are based upon weight and flight or ground personnel overhead factors. The model compares nine separate configurations and extends from FY 1987 through the first ten years of Space Station operations. A spreadsheet format together with a grouping of the program constraints promotes rapid recalculations when new input data is desired. Author

A87-38769* Grumman Aerospace Corp., Bethpage, N.Y.
ADVANCED ORBITAL SERVICING CAPABILITIES DEVELOPMENT
ROY E. OLSEN (Grumman Corp., Bethpage, NY) and ALBERTA QUINN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 719-732.
(Contract NAS8-36427)
(SAE PAPER 860992)

The potential servicing requirements of the Space Station and associated free-flying platforms are identified and analyzed; the selected servicing tasks encompass orbital maneuver vehicle refueling, reaction-control subsystem thruster module replacement, and body-mounted radiator changeout. Attention is presently given to the commonality of all servicing activities, the definition of servicing interfaces, and the roles played by automation and robotics. The servicing concepts for each representative servicing task were selected on the basis of a weighed combination of seven factors: safety, productivity, relative cost, mission effectiveness, design flexibility and simplicity, and development status. O.C.

A87-38780
AN EVALUATION OF OPTIONS TO SATISFY SPACE STATION EVA REQUIREMENTS
JOSEPH J. THOMPSON, KENNETH S. BROSSEL (Boeing Aerospace Co., Seattle, WA), and BRUCE W. WEBBON (SRI International, Menlo Park, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 845-861.
(SAE PAPER 861008)

The Space Station mission requirements for initial frequent use of EVA require the modification of the existing Shuttle suit and the Shuttle Extravehicular Mobility Unit (EMU). Options for a Space Station EVA space suit are described and evaluated in light of the Space Station mission human and environmental requirements. The evaluation is made to select the most cost-effective and technologically feasible alternative that meets the requirements. Requirements considered include: (1) the heavy, almost industrial use, of the suit; (2) long operational life; (3) on-orbit maintenance and fit check; (4) high mobility; (5) rapid don/doff; (6) high pressure for zero pre-breath; (7) radiation protection; (8) micrometeroid/space debris protection; (9) thermal insulation; (10) contamination/decontamination factors; (11) automatic checkout; and (12) low development and recurring costs. Author

A87-38781
AN EVALUATION OF ADVANCED EXTRAVEHICULAR CREW ENCLOSURES
RONALD E. RENMAN and RONALD A. BO (Grumman Aerospace Corp., Bethpage, NY) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 863-871.
(SAE PAPER 861009)

The advanced EVA suits under development by NASA for tasks requiring high levels of mobility and manual dexterity operate at pressures approaching that of the Space Station interior, thereby obviating the oxygen prebreathing otherwise needed to prevent decompression sickness. Attention is given to the prospects for further enhancement of EVA capabilities through the use of hard, shirtsleeve-condition crew enclosures that employ anthropomorphic arms and dextrous manipulators. The enclosure offering best overall performance and lowest total program costs is a high-pressure suit incorporating a fully regenerable life support system, whose high performance rating depends on the assumed future development of gloves furnishing levels of dexterity comparable to those of existing low pressure designs. O.C.

A87-38782
SPACE STATION EVA USING A MANEUVERING ENCLOSURE UNIT
D. PAUL MEYER, JOE J. THOMPSON, and RICHARD L. OLSON (Boeing Aerospace Co., Seattle, WA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 873-882. refs
(SAE PAPER 861010)

An evaluation is made of an EVA enclosure concept that combines features of the Extravehicular Mobility Unit (EMU) and the Manned Maneuvering Unit, and incorporates robotic elements. This Maneuvering Enclosure Unit (MEU) encompasses docking ring and latching mechanisms, an attachment structure for the grappler and manipulator arms, and packaging facilities for life support and data systems. Prospected performance comparisons are made between the MEU and EMU with respect to versatility, consumables usage, operator acceptance, operations, and design/development factors. O.C.

A87-40376
ON-ORBIT ASSEMBLY AND REPAIR
A. JUSTAFERRO, S. C. DEBROCK, H. T. FISHER, G. J. GOULD, S. J. HOUSTON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) et al. IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 221-243.

The concept of on-oribt assembly and repair is introduced including users, tasks, Space Station and NSTS interfaces. Representative missions and spacecraft requiring assembly and repair are briefly described along with the specific service requested. Considerations for setting the level of on-orbit replaceable unit (ORU) indenture or packaging size are discussed along with the feasibility of intravehicular activity (IVA) repair at the component and board level. A discussion of broad design guidelines is presented with reference data in easy-acess, tabular form and finally a listing of more than 15 years of servicing design lessons learned are presented. Author

A87-40377
PLANNING FOR SPACE ROBOTICS DEVELOPMENTS AND APPLICATIONS
DAVID R. CRISWELL (California, University, La Jolla) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 244-250. refs

Recommendations of the Consortium for Space Automation and Robotics concerning ways to improve the effectiveness of humans in space are examined. Consideration is given to design capture of the Space Station, and the use of smart robots on the Space Station. The applications of space automation and robotics to the initial operating configuration; the operation, maintenance, and housekeeping of the Space Station; and the servicing of satellites are discussed. I.F.

A87-41161*# Rockwell International Corp., Canoga Park, Calif.
CONCEPTS FOR SPACE MAINTENANCE OF OTV ENGINES
A. MARTINEZ, B. D. HINES, and C. M. ERICKSON (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Propulsion Meeting, New Orleans, LA, Aug. 25-28, 1986, Paper. 13 p.
(Contract NAS3-23773)

Concepts for space maintainability of OTV engines are examined. The advanced efforts are based on work recently completed for NASA Lewis Research Center Space Propulsion Technology Division. An engine design is developed which is driven by space maintenance requirements and by a failure modes and effects analysis. Modularity within the engine is shown to offer cost benefits and improved space maintenance capabilities. Space-operable disconnects are conceptualized for both engine change-out and for module replacement. Through FME mitigation the modules are conceptualized to contain the most often replaced engine components. A preliminary space maintenance plan is developed around a controls and condition monitoring system using advanced sensors, controls, and conditioning monitoring concepts. Author

A87-41573
THE SINGLE-STAGE REUSABLE BALLISTIC LAUNCHER CONCEPT FOR ECONOMIC CARGO TRANSPORTATION
D. E. KOELLE and W. KLEINAU (MBB-ERNO Raumfahrttechnik GmbH, Ottobrunn, West Germany) (IAF, International Astronautical Congress on Space: New Opportunities for all People, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, p. 125-130.

A design configuration, performance capability and economic feasibility evaluation is presented for an unmanned, ballistic single-stage-to-orbit (SSTO) booster concept designated 'BETA II'. This SSTO, which would both take off and land vertically, is to be propelled by 13 LOX/LH2-fuel advanced topping cycle engines arranged around a heat shield. BETA II would be capable of lofting 15 metric tons to 200-km orbit, or 12 metric tons to the 500-km, 28.5-deg Space Station orbit. The primary advantage of the BETA II vehicle, which is projected for post-year 2000 service, is its extreme simplicity. O.C.

A87-43060*# Sydney Univ. (Australia).
NONEQUILIBRIUM RADIATION DURING RE-ENTRY AT 10 KM/S
G. A. BIRD (Sydney, University, Australia) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 12 p. refs
(Contract NAGW-728)
(AIAA PAPER 87-1543)

The direct simulation Monte Carlo method, including a real air model with thermal radiation, is applied to the flows associated with the two sets of measurements that are directly relevant to the projected aeroassisted orbital transfer vehicle. The first is a shock tube measurement of the radiation from a 10 km/s shock wave in air that was made at AVCO in 1962. The second is the flight data that was obtained from the Project Fire re-entry test vehicles in 1964. The calculations for both cases were made with a program that models the one-dimensional flow along a stagnation streamline. The shock standoff distance for the Fire vehicle was obtained from the theoretical studies that were associated with its launch. The simulation employed a partly phenomenological model for the nonequilibrium radiation. It was found that the results from the calculation were consistent with the measured radiation in each case, and also with the convective heat transfer data for the Fire vehicle. The uncertainties associated with the spectral absorptance and recombination probability at the surface appear to be as serious as those associated with the reaction rates.
Author

A87-45192#
OPERATION OF THE ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM (OSCRS) AT THE SPACE STATION
BARNEY F. GORIN (Fairchild Space Co., Germantown, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San

Diego, CA, June 29-July 2, 1987. 9 p. refs
(AIAA PAPER 87-1768)

The operation of the OSCRS system is examined with reference to the program background, performance requirements, specific design features of the system, and OSCRS/Space Station interfaces. The system will consist of a family of tankers capable of operation in the Orbiter payload bay, at the Space Station, or remotely when transported by the Orbital Maneuvering Vehicle or the Orbit Transfer Vehicle. They will be transported to orbit either in the Orbiter or on the Expendable Launch Vehicle. When depleted of propellant, they will be returned to earth in the Orbiter for refurbishment and reuse. V.L.

A87-45525

GPS APPLICATIONS TO THE SPACE STATION

U. CHENG, J. HOLMES, G. HUTH, R. SCHOLTZ, and K. T. WOO IN: GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 847-851. refs

This paper describes the Space Station's traffic-tracking requirements and reviews arguments which support the conclusion that measurements of Global Positioning System signals can be used to satisfy these requirements. Differential measurement techniques are shown to potentially provide a feasible method for achieving 1 meter location accuracy in proximity operations. Author

A87-46000*# Rockwell International Corp., Canoga Park, Calif.

CONCEPTS FOR SPACE MAINTENANCE OF OTV ENGINES

A. MARTINEZ, B. D. HINES, and C. M. ERICKSON (Rockwell International Corp., Rocketdyne Div., Canoga Park CA) Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Propulsion Meeting, New Orleans, LA, Aug. 1986, Paper. 13 p.
(Contract NAS3-23773)

In this paper, concepts for space maintainability of Orbital Transfer Vehicles engines are examined. An engine design is developed which is driven by space maintenance requirements and by a Failure Modes and Effects Analysis (FMEA). Modularity within the engine is shown to offer cost benefits and improved space maintenance capabilities. Space-operable disconnects are conceptualized for both engine change-out and for module replacement. Through FME mitigation the modules are conceptualized to contain the most often replaced engine components. A preliminary space maintenance plan is developed around a Controls and Condition Monitoring system using advanced sensors, controls, and conditioning monitoring concepts. Author

A87-49618*# Georgia Inst. of Tech., Atlanta.

OPTIMAL HEADING CHANGE WITH MINIMUM ENERGY LOSS FOR A HYPERSONIC GLIDING VEHICLE

ANTHONY J. CALISE and GYOUNG H. BAE (Georgia Institute of Technology, Atlanta) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 417-421. refs
(Contract NAG1-660)
(AIAA PAPER 87-2566)

A three state model is presented for analyzing the problem of optimal changes in heading with minimum energy loss for a hypersonic gliding vehicle. A further model order reduction to a single state model is examined using singular perturbation theory. The optimal solution for the reduced problem defines an optimal altitude profile dependent on the current energy of the vehicle, and the corresponding optimal lift and bank angle. A separate boundary layer analysis, based on an expansion of the necessary conditions about the reduced solution, is used to account for altitude and flight path angle dynamics and to derive a guidance law in feedback form. The guidance law is evaluated for a hypothetical vehicle. Author

N87-20306*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md. Space Welding Project.

GAS TUNGSTEN ARC WELDING IN A MICROGRAVITY ENVIRONMENT: WORK DONE ON GAS PAYLOAD G-169

BLAKE A. WELCHER, FAYSAL A. KOLKAILAH, and ARTHUR H. MUIR, JR. (Rockwell International Corp., Thousand Oaks, Calif.) *In* NASA. Goddard Space Flight Center The 1986 Get Away Special Experimenter's Symposium p 23-29 Feb. 1987
Avail: NTIS HC A11/MF A01 CSCL 11F

GAS payload G-169 is discussed. G-169 contains a computer-controlled Gas Tungsten Arc Welder. The equipment design, problem analysis, and problem solutions are presented. Analysis of data gathered from other microgravity arc welding and terrestrial Gas Tungsten Arc Welding (GTAW) experiments are discussed in relation to the predicted results for the GTAW to be performed in microgravity with payload G-169. Author

N87-20335*# Science Applications International Corp., Schaumberg, Ill. Space Science Dept.

SATELLITE SERVICING MISSION PRELIMINARY COST ESTIMATION MODEL

Jan. 1987 38 p
(Contract NAS9-17207)
(NASA-CR-171978; NAS 1.26:171978; SAIC-87/1514; SAIC-1-120-778-C14) Avail: NTIS HC A03/MF A01 CSCL 22A

The cost model presented is a preliminary methodology for determining a rough order-of-magnitude cost for implementing a satellite servicing mission. Mission implementation, in this context, encompassess all activities associated with mission design and planning, including both flight and ground crew training and systems integration (payload processing) of servicing hardward with the Shuttle. A basic assumption made in developing this cost model is that a generic set of servicing hardware was developed and flight tested, is inventoried, and is maintained by NASA. This implies that all hardware physical and functional interfaces are well known and therefore recurring CITE testing is not required. The development of the cost model algorithms and examples of their use are discussed. B.G.

N87-20628# European Space Agency, Paris (France).

SERVICING OF THE POLAR PLATFORM

G. VALENTINY *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 43-47 Nov. 1986
Avail: NTIS HC A07/MF A01

The use of the ESA shuttle Hermes to service the Columbus space station polar platform is discussed. In-orbit servicing is required to achieve the 20 yr specified lifetime for the platform. Hermes can carry 4 people and a 2 ton payload. A typical servicing scenario is presented. ESA

N87-20641# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

PANEL REPORT ON THE POLAR PLATFORM SERVICING APPROACH AND ITS IMPLICATIONS

B. PFEIFFER *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 107-108 Nov. 1986
Avail: NTIS HC A07/MF A01

Preventive maintenance for polar-platform subsystems and instruments; corrective maintenance for polar-platform subsystems and instruments in the event of failure(s); enhancement of polar-platform capabilities beyond the initial orbit configuration; long-duration missions involving high-repetitivity of Earth observation data; and performing such missions on a cost-effective basis were discussed. A servicing approach and implications and user requirements were reviewed. ESA

N87-22551# General Accounting Office, Washington, D. C.
SPACE OPERATIONS: NASA'S USE OF INFORMATION TECHNOLOGY. REPORT TO THE CHAIRMAN, COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
Apr. 1987 67 p
(GAO/IMTEC-87-20; B-226577) Avail: NTIS HC A04/MF A01

An overview of the information technology that is critical to the missions of NASA are provided. Planning, development, and use of information for three areas (Space Transportation System, space stations, and unmanned space exploration) are discussed.
B.G.

N87-23682# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A MULTIPLE ATTRIBUTE DECISION ANALYSIS OF MANNED AIRLOCK SYSTEMS M.S. Thesis
DENNIS P. JEANES Dec. 1986 128 p
(AD-A179241; AFIT/GSO/ENS/86D-3) Avail: NTIS HC A07/MF A01 CSCL 22B

This study is a multiple attribute decision analysis involving five manned airlock alternatives. The five alternatives are the present shuttle airlock system augmented with additional consumable gas tanks, four variations of the Crewlock, a new airlock design concept proposed by Mr. William Haynes of the Aerospace Corporation. The purpose was to identify which airlock system can best support both the normal shuttle mission extravehicular activity (EVA) and the shuttle's EVA requirements during construction of the space station. Only physical characteristics and performance parameters are included in the analysis. Cost factors are not addressed. The analytic hierarchy process (AHP) was used to structure the problem and helped identify and rate ten airlock attributes, safety, reliability, weight, size, volume, transit time, depressurization time, repressurization time, expendable gas usage, and number of EVA periods per mission. Compromise programming was used to identify the airlock system closest to the ideal solution using the AHP-derived weights.
GRA

N87-25339*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TRACK AND CAPTURE OF THE ORBITER WITH THE SPACE STATION REMOTE MANIPULATOR SYSTEM
E. M. BAINS (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.), C. R. PRICE, and L. M. WALTER May 1987 20 p
(Contract NAS9-17900; NAS9-15800)
(NASA-TM-89221; NAS 1.15:89221) Avail: NTIS HC A02/MF A01 CSCL 22A

Results of the first study using the real-time, man-in-the-loop Systems Engineering Simulator (SES) for track and capture of the Space Shuttle Orbiter with the space station manipulator are presented. The objectives include evaluation of the operational coordination required between the orbiter pilot and the space station manipulator operator, evaluation of the locations and required number of closed-circuit television cameras, and evaluation of the orbiter grapple fixture clearance geometry. The SES is a premium quality real-time facility with full fidelity orbiter and space station crew workstations and cockpits.
Author

N87-25443*# Texas A&M Univ., College Station.
ELECTROCHEMICAL PROCESSING OF SOLID WASTE Semiannual Report, Jul. 1987
JOHN OM. BOCKRIS Jul. 1987 48 p
(Contract NAG9-192)
(NASA-CR-181128; NAS 1.26:181128) Avail: NTIS HC A03/MF A01 CSCL 07D

An investigation of electrochemical waste treatment methods suitable for closed, or partially closed, life support systems for manned space exploration is discussed. The technique being investigated involves the electrolysis of solid waste where the aim is to upgrade waste material (mainly fecal waste) to generate gases that can be recycled in a space station or planetary space environment.
Author

N87-26097*# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.
CONCEPTS FOR SPACE MAINTENANCE OF OTV ENGINES Interim Report
A. MARTINEZ, B. D. HINES, and C. M. ERICKSON *In* Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1 p 99-110 Aug. 1986
(Contract NAS3-23773)
Avail: NTIS HC A25/MF A01 CSCL 21H

Concepts for space maintainability of the Orbital Transfer Vehicle (OTV) engines are examined. An engine design is developed which is driven by space maintenance requirements and by a failure modes and effects analysis (FMEA). Modularity within the engine is shown to offer cost benefits and improved space maintenance capabilities. Space-operable disconnects are conceptualized for both engine change-out and for module replacement. A preliminary space maintenance plan is developed around a controls and condition monitoring system using advanced sensors, controls, and condition monitoring concepts.
Author

N87-26181*# Vanderbilt Univ., Nashville, Tenn. Dept. of Physics and Astronomy.
THE ROLE OF ELECTRONIC MECHANISMS IN SURFACE EROSION AND GLOW PHENOMENA
RICHARD F. HAGLUND, JR. *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 63-74 1 Jun. 1987 Sponsored in part by Air Force; Navy; Los Alamos National Lab., N. Mex.; Sandia National Lab., Albuquerque, N. Mex.; and Martin-Marietta Corp.
Avail: NTIS HC A09/MF A01 CSCL 07D

Experimental studies of desorption induced by electronic transitions (DIET) are described. Such studies are producing an increasingly complete picture of the dynamical pathways through which incident electronic energy is absorbed and rechanneled to produce macroscopic erosion and glow. These mechanistic studies can determine rate constants for erosion and glow processes in model materials and provide valuable guidance in materials selection and development. Extensive experiments with electron, photon, and heavy particle irradiation of alkali halides and other simple model materials have produced evidence showing that: (1) surface erosion, consisting primarily in the ejection or desorption of ground-state neutral atoms, occurs with large efficiencies for all irradiated species; (2) surface glow, resulting from the radiative decay of desorbed atoms, likewise occurs for all irradiating species; (3) the typical mechanism for ground-state neutral desorption is exciton formation, followed by relaxation to a permanent, mobile electronic defect which is the precursor to bond-breaking in the surface or near-surface bulk of the material; and (4) the mechanisms for excited atom formation may include curve crossing in atomic collisions, interactions with surface defect or impurity states, or defect diffusion.
M.G.

N87-26927*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
SINGULAR PERTURBATION ANALYSIS OF AOTV RELATED TRAJECTORY OPTIMIZATION PROBLEMS Progress Report, 14 Apr. - 30 Oct. 1986
ANTHONY J. CALISE Nov. 1986 16 p
(Contract NAG1-660)
(NASA-CR-180301; NAS 1.26:180301) Avail: NTIS HC A02/MF A01 CSCL 22A

The problem of aeroassisted orbital plane change is discussed. This maneuver requires the use of three impulses - one to deorbit, one to reorbit and one to recircularize at the new orbit. The orbit plane change is effected entirely in the atmosphere through the use of lift and bank angle control. For circular orbits of nearly equal radii, it can be shown that the fuel consumption is reduced by minimizing the energy loss in the atmospheric portion of the trajectory. The research explores the use of singular perturbation theory to develop an optimal guidance law for the atmospheric portion.
Author

N87-28577 Michigan Univ., Ann Arbor.
OPTIMAL NODAL TRANSFER AND AEROASSISTED TRANSFER BY AEROCRUISE Ph.D. Thesis
SHAU-HERN KUO 1987 165 p
Avail: Univ. Microfilms Order No. DA8712155

In view of the increasing human activity in space, the maneuvering between different orbits is going to be a regular and also an important part of space transportation. Some contributions are provided to the problem of minimum fuel, time-free transfer between non-coplanar elliptical orbits both in the pure propulsive mode and the aeroassisted mode. The reference gain introduced gives a good initial guess and can solve all the two impulse time-free orbital transfer problems, and have a better evaluation between the propulsive transfer and the aeroassisted orbital transfer. From the discovery of the closeness between the minimum nodal transfer and the true optimum transfer, the former can be used as a good approximation and checkout the latter. Also the general view about the permissible thrust angles and the impulse position restriction can give a guide in designing a near optimal orbit transfer. The optimal control problem in aerocruise at constant altitude reveals that the optimal control strategy is better than the result from parameter optimization, not only for the plane change ability but also in reducing the acceleration load. Dissert. Abstr.

N87-28588# Selenia S.p.A., Rome (Italy).
RENDEZVOUS AND DOCKING (RVD) LONG RANGE RF SENSOR DEFINITION STUDY, EXECUTIVE SUMMARY
Paris, France ESA 1986 114 p
(Contract ESA-6093/84-NL-GM(SC))
(SES/ENG/ES-519/86; ESA-CR(P)-2367; ETN-87-90471) Avail: NTIS HC A06/MF A01

A 90 GHz radar, an S-band lobe switching sensor, and S-band phase switching sensors were compared for use as rendezvous and docking long range sensor aboard the chaser satellite. The lobe switching concept best meets requirements of target satellite acquisition (at a range of the order of 100 km) and operation at a range less than 100 m; measurement of relative distance (between chaser and target) with accuracy of 1 m (at short range); measurement of relative velocity (between chaser and target) with accuracy of 1 cm/sec (at short range); measurement of relative position (between chaser and target) expressed as bearing angles with respect to reference frame in the chaser, with accuracy of 0.5 deg in the field of view of +/- 30 deg; and measurement of bearing angle rates with respect to the reference frame in the chaser with accuracy of 0.05 deg/sec. ESA

N87-29168*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
KSC SPACE STATION OPERATIONS LANGUAGE (SSOL)
In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 22 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

The Space Station Operations Language (SSOL) will serve a large community of diverse users dealing with the integration and checkout of Space Station modules. Kennedy Space Center's plan to achieve Level A specification of the SSOL system, encompassing both its language and its automated support environment, is presented in the format of a briefing. The SSOL concept is a collection of fundamental elements that span languages, operating systems, software development, software tools and several user classes. The approach outlines a thorough process that combines the benefits of rapid prototyping with a coordinated requirements gathering effort, yielding a Level A specification of the SSOL requirements. Author

N87-29677*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION BASED OPTIONS FOR ORBITER DOCKING/BERTHING
DANIEL J. HOOVER *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium p 261-273 May 1987
Avail: NTIS HC A16/MF A01 CSCL 22B

Conceptual efforts to develop a Space Station based system for docking and/or berthing the NSTS Orbiter are described. Past docking and berthing systems are reviewed, the general requirements and options for mating the Orbiter and Space Station are discussed, and the rationale for locating the system on the Station is established. One class of Station-based system is developed in several variations and evaluated with respect to weight distribution, loads, safety, reliability, viewing, and maintainability. An evolutionary presentation of the variations provides insight into the development process and the problems encountered. An overall evaluation of the Station-based variations compared to an optimized Orbiter-based system demonstrates the potential benefits of this approach as well as the issues that must be resolved to realize the benefits. Author

N87-29678*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AN ELECTROMECHANICAL ATTENUATOR/ACTUATOR FOR SPACE STATION DOCKING
LEBARIAN STOKES, DEAN GLENN, and MONTY B. CARROLL (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.) *In its* The 21st Aerospace Mechanisms Symposium p 275-284 May 1987
Avail: NTIS HC A16/MF A01 CSCL 22B

The development of a docking system for aerospace vehicles has identified the need for reusable and variably controlled attenuators/actuators for energy absorption and compliance. One approach to providing both the attenuator and the actuator functions is by way of an electromechanical attenuator/actuator (EMAA) as opposed to a hydraulic system. The use of the electromechanical devices is considered to be more suitable for a space environment because of the absence of contamination from hydraulic fluid leaks and because of the cost effectiveness of maintenance. A smart EMAA that uses range/rate/attitude sensor information to preadjust a docking interface to eliminate misalignments and to minimize contact and stroking forces is described. A prototype EMAA was fabricated and is being tested and evaluated. Results of preliminary testing and analysis already performed have established confidence that this concept is feasible and will provide the desired reliability and low maintenance for repetitive long term operation typical of Space Station requirements. Author

17

SPACE ENVIRONMENT

Includes description of the space environment and effects on Space Station subsystems. Includes requirements for Space Station to accommodate this environment.

A87-34480*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
POTENTIAL MODULATION ON THE SCATHA SPACECRAFT
P. D. CRAVEN (NASA, Marshall Space Flight Center, Huntsville, AL), R. C. OLSEN (Alabama, University, Huntsville), J. FENNELL, D. CROLEY (Aerospace Corp., Los Angeles, CA), and T. AGGSON (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Mar.-Apr. 1987, p. 150-157. refs
(Contract F04701-85-C-0086; NAS8-33982)

A small (1-V) modulation of the spacecraft potential is observed on the SCATHA satellite through its effects on the data from four instruments: two particle detectors and two field detectors. It is shown that there is a strong causal link between the modulation of the potential at this 1-V level and a nonuniform distribution of the photoemissive properties of the conducting material on the surface of the satellite. Author

A87-38622

MARTIN MARIETTA ATOMIC OXYGEN BEAM FACILITY

GARY W. SJOLANDER and LYLE E. BAREISS (Martin Marietta Corp., Denver, CO) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 722-731. refs

An atomic oxygen (AO) beam facility for the investigation of atomic oxygen interaction on space related material surfaces is described. The 5-eV beam energy and 10 to the 14th - 10 to the 15th/sq cm per sec atomic oxygen flux simulate the low earth orbit oxygen environment. The AO apparatus combined with a solar simulator and a controllable residual background allows the investigation of various synergistic effects that play a role in Shuttle bay chemistry. The combined goals for this facility include developing a fundamental understanding of AO surface interactions and the screening of space materials for long duration missions. Author

A87-38623* Physical Sciences, Inc., Andover, Mass.

A HIGH FLUX PULSED SOURCE OF ENERGETIC ATOMIC OXYGEN

ROBERT H. KRECH and GEORGE E. CALEDONIA (Physical Sciences, Inc., Andover, MA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 752-760. refs
(Contract NAS7-936)

The design and demonstration of a pulsed high flux source of nearly monoenergetic atomic oxygen are reported. In the present test setup, molecular oxygen under several atmospheres of pressure is introduced into an evacuated supersonic expansion nozzle through a pulsed molecular beam valve. A 10J CO2 TEA laser is focused to intensities greater than 10 to the 9th W/sq cm in the nozzle throat, generating a laser-induced breakdown with a resulting 20,000-K plasma. Plasma expansion is confined by the nozzle geometry to promote rapid electron-ion recombination. Average O-atom beam velocities from 5-13 km/s at fluxes up to 10 to the 18th atoms/pulse are measured, and a similar surface oxygen enrichment in polyethylene samples to that obtained on the STS-8 mission is found. R.R.

A87-38624

PRODUCTION OF A BEAM OF GROUND STATE OXYGEN ATOMS OF SELECTABLE ENERGY

RAYMOND D. REMPT (Boeing Aerospace Co., Seattle, WA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 761-769.

A method for the production of a fast neutral beam of ground state oxygen atoms with selectable energy from 1/2-20 electron volts is described, with application to the examination and qualification of test material types for LEO deployment. O(-) ions are produced by resonance dissociative attachment of N2O, and the negative ions are then electrostatically accelerated to the desired energy and presented to the laser beam (whose wavelength is shorter than the corresponding electron affinity of the oxygen atom). The resultant beam contains only ground state atoms, and the process may be used to produce a fast atomic nitrogen or hydrogen beam. It is predicted that fluxes of 10 to the 15th atoms/sq cm sec are possible with the present method. R.R.

A87-38643* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPACE ENVIRONMENTAL EFFECTS ON ADHESIVES FOR THE GALILEO SPACECRAFT

F. L. BOUQUET and T. HASEGAWA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1101-1110. refs

Requirements for the adhesives used on the Galileo Jovian probe are discussed, and the results of mechanical and radiation experiments for their qualification are presented. The five types of adhesives used for the Wide Field Camera, SXA Antenna, temperature control louvers, and structural bonds all passed the proton and electron tests and the low temperature radiation tests. Possible bond improvements through techniques including gamma ray radiation exposure and ion implantation are also considered. R.R.

A87-38715* National Aeronautics and Space Administration, Washington, D.C.

RADIATION DOSE PREDICTION FOR SPACE STATION

PERCIVAL D. MCCORMACK (NASA, Office of the Space Station, Washington, DC) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 123-140. refs
(SAE PAPER 860924)

A detailed examination is conducted of the basis for the significant differences in Space Station radiation dose predictions that result from magnetic field model extrapolations into the future, with attention to the radiation attenuation effects of the residual atmospheric layer at altitudes of less than 1000 km. A model adjustment is proposed to supplant the arbitrary procedure of magnetic field extrapolation into the future. At altitudes below 500 km and low inclination, and with nominal module wall thicknesses, the new predictions for a 90-day Space Station tour are found to be well within current radiation dose limit guidelines. O.C.

A87-44392

ORBITAL DEBRIS ENVIRONMENT RESULTING FROM FUTURE ACTIVITIES IN SPACE

SHIN-YI SU (National Central University, Chung-Li, Republic of China) (COSPAR and IAF, Plenary Meeting, 26th, Topical Meetings and Workshop on Cosmic Dust and Space Debris, 6th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 7, 1986, p. 109-117. refs

A long-term evolution of space debris environment has been simulated by a numerical model. Based on previously published results in many 50-year runs of the 'dynamic model', an 'average model' is derived to reduce the computation time in order to effectively simulate a very-long-term evolution of space debris environment. The evolution of space debris environment is examined with two different future space activities in LEO: (1) involving an increase of the yearly traffic input of new satellites by 2, 5, 10, 20, and 50 percent; and (2) placing ten large space structures of 100 meters diameter in the year 1995 at either 500-km or 1000-km altitude. The results indicate that in a 170-year span from 1983, every space activity listed above results in a rapid runaway of debris fluxes from objects of 4 mm or larger. Author

A87-49026* California Univ., Berkeley.

RADIATION ENVIRONMENTS AND ABSORBED DOSE ESTIMATIONS ON MANNED SPACE MISSIONS

S. B. CURTIS (California, University, Berkeley), W. ATWELL, R. BEEVER (Rockwell International Corp., Houston, TX), and A. HARDY (NASA, Johnson Space Center, Houston, TX) (COSPAR and National Council on Radiation Protection and Measurements, Plenary Meeting, 26th, Topical Meeting and Workshop VII on Life Sciences and Space Research XXII/1/, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 11, 1986, p. 269-274. refs

The dose and dose-equivalent estimates that astronauts might be expected to receive in space were assessed for the development of new radiation protection guidelines, considering several space mission scenarios. These scenarios included a 90-day LEO mission at 450 km altitude with orbital inclinations appropriate for NASA's Space Station (28.5, 57, and 90 deg), a 15-day sortie to GEO, and a 90-day lunar mission. All the missions contemplated would present space travelers with dose equivalents between 5 and 10 rem to the blood-forming organs, assuming no encounter with a large solar particle event; a large particle event could add considerable exposure for all scenarios except for the one at 28.5 orbital inclination. Adequate shielding must be included to guard against the radiation produced by such events. I.S.

A87-51713* Maxwell Labs., Inc., San Diego, Calif.
RAM ION SCATTERING CAUSED BY SPACE SHUTTLE V X B INDUCED DIFFERENTIAL CHARGING
I. KATZ and V. A. DAVIS (Maxwell Laboratories, Inc., S-Cubed Div., La Jolla, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Aug. 1, 1987, p. 8787-8791. refs
(Contract NAS3-23881)

Observations of secondary, high-inclination ions streams have been reported in the literature. The authors of these previous papers attributed the source of the secondary ions to a disturbed region in the plasma about 10 m from the Space Shuttle Orbiter. A new theory has been developed which shows how v x B induced differential charging on the plasma diagnostics package (PDP) can scatter the ram ion flux. Some of these ions are reflected back to the PDP and may be the sorce of the observed ion distributions. The effect is unique to large spacecraft; it occurs only when the magnitude of the induced v x B potentials are much larger than the electron thermal energy and of the order of the ion ram energy. That the ion streams observed at large angles must have been reflected from the PDP surface is demonstrated with three-dimensional sheath and particle trajectory calculations using the low earth orbit version of the NASA Charging Analyzer Program (NASCAP/LEO). Author

N87-20795*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DOCUMENTATION OF THE SPACE STATION/AIRCRAFT ACOUSTIC APPARATUS
SHERMAN A. CLEVENSON Feb. 1987 32 p
(NASA-TM-89111; NAS 1.15:89111) Avail: NTIS HC A03/MF A01 CSCL 20A

This paper documents the design and construction of the Space Station/Aircraft Acoustic Apparatus (SS/AAA). Its capabilities both as a space station acoustic simulator and as an aircraft acoustic simulator are described. Also indicated are the considerations which ultimately resulted in man-rating the SS/AAA. In addition, the results of noise surveys and reverberation time and absorption coefficient measurements are included. Author

N87-21024# Aerospace Corp., El Segundo, Calif. Space Sciences Lab.
POTENTIAL MODULATIONS ON SCATHA (SPACECRAFT CHARGING AT HIGH ALTITUDE) SPACECRAFT
P. D. CRAVEN, R. C. OLSEN, T. AGGSON, J. F. FENNELL, and D. R. CROLEY, JR. 30 Sep. 1986 36 p
(Contract F04701-85-C-0086)
(AD-A176815; TR-0086(6940-05)-13; SD-TR-86-92) Avail: NTIS HC A03/MF A01 CSCL 04A

A small (1 volt) modulation of the spacecraft potential is observed on the SCATHA satellite through its effects on four instruments, two particle detectors and two field detectors. It is shown that there is a strong causal link between the modulation of the potential at this 1 volt level and a nonuniform distribution of the photoemissive properties of the conducting material on the surface of the satellite. GRA

N87-21991# Severn Communications Corp., Severna Park, Md.
RADIATION SHIELDING REQUIREMENTS ON LONG-DURATION SPACE MISSIONS
JOHN R. LETAW and SCOTT CLEARWATER 21 Jul. 1986 40 p Prepared in cooperation with Los Alamos National Lab., N. Mex.
(Contract N00014-85-C-2200)
(AD-A177512; SCC-86-02) Avail: NTIS HC A03/MF A01 CSCL 22A

An analysis of radiation shielding requirements on long duration space missions is presented. The report finds the principal radiation hazards to be galactic cosmic radiation (cosmic rays) and radiation from solar flares. Galactic cosmic radiation is a continuous source of radiation delivering a dose equivalent to the blood-forming organs varying from 20 REM/year to 50 REM/year over the 11 year solar cycle. Solar flares are randomly distributed events which are occasionally associated with lethal particle fluxes. The following recommendations are made: Investigate alternative shielding materials which may be more effective against radiation hazards discussed here; A solar flare storm shelter with a minimum of 7.5 cm aluminum shielding (or shielding of equivalent effect) is required at all times for spaceflights outside the magnetosphere. Spacecraft designed to transport people outside the magnetosphere for long durations during solar minimum must provide at least 7.5 cm aluminum shielding of all living spaces. Acceptable dose limits for the full scale exploration and industrialization of space must be studied. GRA

N87-23066*# Massachusetts Inst. of Tech., Cambridge. Plasma Fusion Center.
A PRELIMINARY STUDY OF EXTENDED MAGNETIC FIELD STRUCTURES IN THE IONOSPHERE Status Report
JAMES D. SULLIVAN, BARTON G. LANE, and RICHARD S. POST 18 Jun. 1987 21 p
(Contract NAG5-874)
(NASA-CR-181004; NAS 1.26:181004) Avail: NTIS HC A02/MF A01 CSCL 04A

Several plasma phenomena which are to be expected around a magnet in LEO were identified and analyzed qualitatively. The ASTROMAG cusp magnet will create an extended field whose strength drops to the ambient level over a scale length of approx. 15 m; the combined field has a complex topology with ring nulls and open and closed field lines. The entire configuration is moving through the partially ionized F-layer of the ionosphere at a speed slow compared to the local Alfven speed but fast compared to the ion sound speed. The ambient plasma crosses the extended field structure in a time short compared to the ion Larmor period yet long relative to the electron Larmor period. Thus, electrons behave as a magnetized fluid while ions move ballistically until reflected from higher fields near the cusp. Since the Debye length is short compared to the field scale length, an electrostatic shock-like structure forms to equilibrate the flows and achieve quasi-neutrality. The ambient plasma will be excluded from a cavity near the magnet. The size and nature of the strong interaction region in which the magnet significantly perturbs the ambient flow were determined by studying ion orbits numerically. Lecture viewgraphs summarizing these results are presented. M.G.

N87-23678# TRW Space Technology Labs., Redondo Beach, Calif. System Integration Lab.
SPACECRAFT ENVIRONMENT INTERACTION INVESTIGATION Final Report, Oct. 1983 - Sep. 1986
N. J. STEVENS and MARC E. KIRKPATRICK Oct. 1986 175 p
(Contract F19628-84-C-0038)
(AD-A179183; TRW-43543-6011-UE-00; AFGL-TR-86-0214)
Avail: NTIS HC A08/MF A01 CSCL 22B

This report summarizes the results of the spacecraft environment interaction investigation. The objectives of this investigation were to characterize environmental interaction technology and to determine the adequacy of present military standards and handbooks for future, large AF missions. The characterization of the technology status was accomplished by literature searches and key-expert questionnaires. The determination of military standard adequacy was accomplished by considering interactions with five concepts synthesized from those available in the MSSTP. Based on these concepts studies, critical interactions were identified. The available military documentation was searched for applicability. A recommended document development plan was prepared along with a discussion of technology gaps. GRA

N87-24515 Colorado Univ., Boulder.
SIMULATION OF ON-ORBIT SATELLITE FRAGMENTATION Ph.D. Thesis
DARREN SCOTT MCKNIGHT 1986 241 p
Avail: Univ. Microfilms Order No. DA8706439

The debris from nearly ninety satellites that have fragmented pose a serious hazard to all space systems in Earth orbit. A program has been developed which simulates fragmentation events whose magnitude, size distribution, velocity distribution, geometry, and location of breakup may all be controlled. This numerical model simulates in-orbit satellite fragmentations generating debris fragments across the entire size spectrum, many of which would be nondetectable by the NORAD Space Network. Monte Carlo methods are used to generate the size and velocity distributions of fragments according to hypothetical distributions derived from laboratory experiments. After breakup, the particles' orbits are propagated under the influence of drag and the J sub 2 gravitational term. This simulation program provides insight into the nontrackable debris population available through no other means. The simulation of the Kosmos 1275 breakup supports the speculation that it is the first accidental collision-induced satellite breakup.
Dissert. Abstr.

N87-26082*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
CONTAMINATION ASSESSMENT FOR OSSA SPACE STATION IOC PAYLOADS Final Report, 25 Jul. 1986 - 25 Jul. 1987
S. T. WU Aug. 1987 137 p
(Contract NAG8-592)
(NASA-CR-181165; NAS 1.26:181165) Avail: NTIS HC A07/MF A01 CSCL 22B

An assessment is made of NASA/OSSA space station IOC payloads. The report has two main objectives, i.e., to provide realistic contamination requirements for space station attached payloads, serviced payloads and platforms, and to determine unknowns or major impacts requiring further assessment. Author

N87-26173*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE NASA WORKSHOP ON ATOMIC OXYGEN EFFECTS
DAVID E. BRINZA, ed. 1 Jun. 1987 195 p Workshop held in Pasadena, Calif., 10-11 Nov. 1986
(Contract NAS7-918)
(NASA-CR-181163; JPL-PUB-87-14; NAS 1.26:181163) Avail: NTIS HC A09/MF A01 CSCL 07D

A workshop was held to address the scientific issues concerning the effects of atomic oxygen on materials in the low Earth orbital (LEO) environment. The program included 18 invited speakers plus contributed posters covering topics such as LEO spaceflight experiments, interaction mechanisms, and atomic oxygen source development. Discussion sessions were also held to organize a test program to evaluate atomic oxygen exposure facilities. The key issues raised in the workshop were: (1) the need to develop a reliable predictive model of the effects of long-term exposure of materials to the LEO environment; (2) the ability of ground-based exposure facilities to provide useful data for development of durable materials; and (3) accurate determination of the composition of the LEO environment. These proceedings include the invited papers, the abstracts for the contributed posters, and an account of the test program discussion sessions.

N87-26176*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MASS SPECTROMETERS AND ATOMIC OXYGEN
D. E. HUNTON, E. TRZCINSKI, J. B. CROSS, L. H. SPANGLER, M. H. HOFFBAUER, F. H. ARCHULETA (Los Alamos National Lab., N. Mex.), and J. T. VISENTINE *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 21-28 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

The likely role of atmospheric atomic oxygen in the recession of spacecraft surfaces and in the shuttle glow has revived interest in the accurate measurement of atomic oxygen densities in the upper atmosphere. The Air Force Geophysics Laboratory is supplying a quadrupole mass spectrometer for a materials interactions flight experiment being planned by the Johnson Space Center. The mass spectrometer will measure the flux of oxygen on test materials and will also identify the products of surface reactions. The instrument will be calibrated at a new facility for producing high energy beams of atomic oxygen at the Los Alamos National Laboratory. The plans for these calibration experiments are summarized. Author

N87-26178*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
O-ATOM DEGRADATION MECHANISMS OF MATERIALS
DANIEL R. COULTER, RANTY H. LIANG, SHIRLEY Y. CHUNG, KERI ODA SMITH, and AMITAVA GUPTA *In its* Proceedings of the NASA Workshop on Atomic Oxygen Effects p 39-46 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

The low Earth orbit environment is described and the critical issues relating to oxygen atom degradation are discussed. Some analytic techniques for studying the problem and preliminary results on the underlying degradation mechanisms are presented.
Author

N87-26179*# National Bureau of Standards, Gaithersburg, Md. Chemical Kinetics Div.
KINETICS AND MECHANISMS OF SOME ATOMIC OXYGEN REACTIONS
R. J. CVETANOVIC *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 47-54 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Mechanisms and kinetics of some reactions of the ground state of oxygen atoms, O(3P), are briefly summarized. Attention is given to reactions of oxygen atoms with several different types of organic and inorganic compounds such as alkanes, alkenes, alkynes, aromatics, and some oxygen, nitrogen, halogen and sulfur derivatives of these compounds. References to some recent compilations and critical evaluations of reaction rate constants are given. Author

N87-26183*# Chicago Univ., Ill.
DYNAMICS OF ATOM-SURFACE INTERACTIONS Abstract Only
STEVEN J. SIBENER *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 89 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Scattering techniques currently being used to examine the dynamics and energetics of gas-surface energy exchange processes and gas-surface reaction mechanisms are reviewed. In particular, recent inelastic scattering measurements are highlighted which are revealing the microscopic basis for collision-induced gas-surface energy exchange, e.g., which surface vibrational modes actively participate in translational energy accommodation. Reactive scattering and laser desorptive experiments which examine energy disposal in volatile products are also discussed. Finally, an efficient atomic oxygen beam source is described which is suitable for terrestrial studies of gas-surface interactions. Author

N87-26186*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
HIGH INTENSITY 5 EV ATOMIC OXYGEN SOURCE AND LOW EARTH ORBIT (LEO) SIMULATION FACILITY
J. B. CROSS, L. H. SPANGLER, M. A. HOFFBAUER, F. A. ARCHULETA (Los Alamos National Lab., N. Mex.), LUBERT LEGER, and JAMES VISENTINE *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 105-117 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

An atomic oxygen exposure facility has been developed for studies of material degradation. The goal of these studies is to provide design criteria and information for the manufacture of long life (20 to 30 years) construction materials for use in LEO. The studies that are being undertaken using the facility will provide: absolute reaction cross sections for use in engineering design problems; formulations of reaction mechanisms; and calibration of flight hardware (mass spectrometers, etc.) in order to directly relate experiments performed in LEO to ground based investigations. The facility consists of: (1) a CW laser sustained discharge source of O atoms having a variable energy up to 5 eV and an intensity between 10(15) and 10(17) O atoms s(-1) cm(-2); (2) an atomic beam formation and diagnostics system consisting of various stages of differential pumping, a mass spectrometer detector, and a time of flight analyzer; (3) a spinning rotor viscometer for absolute O atom flux measurements; and (4) provision for using the system for calibration of actual flight instruments. Surface analysis equipment is available for the characterization of material surfaces before and after exposure to O atoms. Author

N87-26204*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARTIN MARIETTA ATOMIC OXYGEN LOW EARTH ORBIT (LEO) SIMULATION Abstract Only
GARY W. SJOLANDER and LYLE BAREISS *In its* Proceedings of the NASA Workshop on Atomic Oxygen Effects p 168 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 14B

An atomic oxygen beam apparatus that produces flux levels and atomic kinetic energy similar to that encountered by spacecraft in low Earth orbit (LEO) is described. The beam apparatus consists of an electric discharge ion source, mass filter, decelerator, and neutralizer. Specific design goals include a 1.3 cm beam diameter, a 5 eV beam energy, and a flux density on the order of 10(15) cm(-2) s(-1). The total fluence will be on the order of 10(19) cm(-2) for an 8 hour test. The neutral oxygen beam will expose various materials contained within a large target chamber. Within the chamber will be a rather complex suite of instrumentation that will allow real-time studies of material mass loss and reactant species spatial distribution. In addition, a UV solar simulator will aid in the understanding of various synergistic effects. Author

N87-26207*# Communications Research Centre, Ottawa (Ontario).
EFFECT OF LONG-TERM EXPOSURE TO LOW EARTH ORBIT (LEO) SPACE ENVIRONMENT
D. G. ZIMCIK *In* Jet Propulsion Lab., Proceedings of the NASA Workshop on Atomic Oxygen Effects p 171 1 Jun. 1987
Avail: NTIS HC A09/MF A01 CSCL 07D

Data obtained from components and materials from the Solar Maximum Mission satellite are presented and compared to data for similar materials obtained from the Advanced Composite Materials Exposure to Space Experiment (ACOMEX) flown on Shuttle mission STS-41G. In addition to evaluation of surface erosion and mass loss that may be of importance to very long-term missions, comparisons of solar absorptance and thermal emittance measurements for both long and short term exposures were made. Although the ratio of absorptance over emittance can be altered by proper choice of materials to ensure a proper operating environment for the spacecraft, once the thermal design is established, it is important that the material properties not change in order to maintain the operating environment for many payload and bus items such as electronics, batteries, fuel, etc. However, data presented show significant changes after short exposure in low Earth environment. Moreover, the measured changes are shown to differ according to the manner of exposure, i.e., normal or oblique, which also affects the resultant eroded surface morphology. These results identify constraints to be considered in development of flight experiments or laboratory testing. Author

N87-26937# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Electromagnetic Wave Propagation Panel.
THE AEROSPACE ENVIRONMENT AT HIGH ALTITUDES AND ITS IMPLICATIONS FOR SPACECRAFT CHARGING AND COMMUNICATIONS
May 1987 286 p In ENGLISH and FRENCH Symposium held in The Hague, Netherlands, 2-6 Jun. 1986
(AGARD-CP-406; ISBN-92-835-0418-6; AD-A185880) Avail: NTIS HC A13/MF A01 CSCL 22B

The symposium examined how the magnetosphere and polar plasmas vary as a result of natural causes and man-made perturbations, and the implications of these variations for the charging and differential charging of spacecraft with their effects, in turn, on spacecraft systems and communications. A better understanding of these phenomena can help to design of spacecraft systems and subsystems to minimize the effects of these disturbances.

N87-26942# Royal Aircraft Establishment, Farnborough (England). Radio and Navigation Dept.
THE USE OF PI2 PULSATIONS AS INDICATORS OF SUBSTORM EFFECTS AT GEOSTATIONARY ORBIT
M. LESTER *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 9 p May 1987
Avail: NTIS HC A13/MF A01

Some of the characteristics of Pi2 pulsations observed at mid-latitudes on the ground are reviewed and the use of certain characteristics in indicating various magnetic and particle perturbations occurring during substorms are assessed. Spacecraft charging and its effects at geosynchronous orbit also reviewed. There is a brief discussion of how Pi2 pulsations might be used to predict intervals of spacecraft charging at geosynchronous orbit. Author

N87-26946*# Alabama Univ., Huntsville. Dept. of Physics.
ELECTRON BEAM EXPERIMENTS AT HIGH ALTITUDES
R. C. OLSEN *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 8 p May 1987
(Contract NAG3-620)
Avail: NTIS HC A13/MF A01 CSCL 22B

Experiments with the electron gun on the SCATHA satellite produced evidence of beam-plasma interactions, and heating of the low energy electrons around the satellite. These experiments were conducted near geosynchronous orbit, in the dusk bulge, and plasma sheet, with one short operation in the lobe regions, providing a range of ambient plasma densities. The electron gun was operated at 50 eV, with beam currents of 1, 10, and 100 micro-A. Data from electrostatic analyzers and the DC electric field experiment show that the satellite charged to near the beam energy in sunlight, if the beam current was sufficient. Higher ambient densities required higher beam currents. The electrostatic analyzers showed distribution functions which had peaks, or plateaus, at energies greater than the satellite potential. These measurements indicate heating of the ambient plasma at several Debye lengths from the satellite, with the heated plasma then accelerated into the satellite. It is likely that the ambient plasma is in fact the photoelectron sheath generated by the satellite. Author

N87-26949# York Univ., Toronto (Ontario). Dept. of Physics.
SPACECRAFT CHARGING IN THE AURORAL PLASMA: PROGRESS TOWARD UNDERSTANDING THE PHYSICAL EFFECTS INVOLVED
J. G. LAFRAMBOISE and L. W. PARKER (Parker, Lee W., Inc., Concord, Mass) *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 16 p May 1987
(Contract F19628-83-K-0028)
Avail: NTIS HC A13/MF A01

The main differences between the plasma environments in geostationary orbit and low polar orbit with respect to high-voltage charging situations are reviewed. Results are presented from a calculation of secondary electron escape currents from negatively charged spacecraft surfaces having various orientations relative to the local magnetic field direction. A simple rough estimate of the required conditions for high-voltage auroral-zone charging is developed. The results suggest that for any given spacecraft, surface potentials are likely to depend more strongly on the ratio of ambient flux of high-energy electrons to that of all ions, than any other environmental parameter. Preliminary results of simulation work directed toward testing this hypothesis are presented. Author

N87-26952# Toronto Univ. (Ontario). Dept. of Electrical Engineering.

ARC PROPAGATION, EMISSION AND DAMAGE ON SPACECRAFT DIELECTRICS

K. G. BALMAIN *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 7 p May 1987
Avail: NTIS HC A13/MF A01

A review is given of the literature on the subject of arc discharges on spacecraft dielectric materials which have become charged by energetic electrons and ions. Arcs resulting from the charging of spacecraft dielectrics can be very strong because the charge over a large area is mobilized through the phenomenon of arc propagation. The resultant damage patterns on the dielectric are shown to be related to arc patterns, and to the optical anisotropy and crystallinity of the material. The evidence for dielectric melting is suggestive of likely contamination of nearby surfaces. The effectiveness of arc barriers sheds light on arc propagation mechanisms. Author

N87-26954# ERA Ltd., Leatherhead (England). Applied Physics Dept.

RADIATION CHARGING AND BREAKDOWN OF INSULATORS

D. K. DAVIES *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 7 p May 1987
Avail: NTIS HC A13/MF A01

An experimental investigation of the charge produced by photo-emission from insulators in vacuo is described. It is shown that the emission from materials commonly used in spacecraft construction, such as polyimide, as well described by solid state theory, but that externally applied fields modify both the emission dynamics as well as the eventual saturation charge density. The energetics of the electric breakdown of such charged surfaces is analyzed. Author

N87-26957# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Community Satellites Dept.

ELECTROSTATIC IMMUNITY OF GEOSTATIONARY SATELLITES

HORST G. LECHTE *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 8 p May 1987
Avail: NTIS HC A13/MF A01

It is demonstrated that electrostatic immunity of telecommunication satellites can be achieved to a large extent by relatively simple means. Those means include the selection of antistatic external materials and the desensitization of electronic actuators and memories regarding fast transients. The dual approach is considered necessary because not all external surfaces can be made antistatic. Protection of operationally critical circuitries against single event upsets is achieved by the same means. Author

18

INTERNATIONAL

Includes descriptions, interfaces and requirements of international payload systems, subsystems and modules considered part of the Space Station system and other international Space Station activities such as the Soviet Salyut.

A87-32279

EUROPE'S FUTURE IN SPACE

MICHEL BIGNIER (ESA, Space Transportation Systems, Paris, France) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 7-12.

The political, scientific, technical, industrial, and economic objectives of the European space program are discussed. The solar terrestrial program, X-ray and stellar spectroscopy studies, and asteroids missions are described. Consideration is given to earth observations, microgravity research, telecommunications, and the development of launchers. Studies on the in-orbit infrastructure for space stations are examined. I.F.

A87-32280

BRITISH ACTIVITIES IN SPACE

D. W. S. LODGE (British National Space Centre, London, England) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 19-24.

British space activities and the involvement of British industry in national and international space programs are discussed. The composition and functions of the British National Space Centre are described. British contributions to the Ariane, Hotol, and Columbus programs; telecommunications; earth observation; and microgravity research are examined. I.F.

A87-32281

THE CANADIAN SPACE PROGRAM

D. I. R. LOW (Ministry of State for Science and Technology, Ottawa, Canada) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 25-30.

The objectives of Canada's space program are examined and a review of Canada's space activities is presented. Canada's involvement in international space projects is discussed. Consideration is given to the Mobile Servicing Centre being designed for the proposed Space Station, Canada's research in space science, the formation of a corps of skilled astronauts, and telecommunications satellite and remote sensing activities. I.F.

A87-32282

HIGHLIGHTS OF THE GERMAN SPACE PROGRAMME

JUERGEN W. BECK (DFVLR, Wessling, West Germany) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 31-35.

The objectives of the major German space projects are discussed. Past activities in space-research and space-technology in manned and unmanned space programs are reviewed. Germany's launched or scheduled scientific, communications, meteorological, and earth observation satellites, and manned space flight activities are examined. Germany's contributions to the proposed ESA programs and U.S. Space Station program are considered. I.F.

A87-32285

JAPANESE SPACE PROGRAM

RYOJIRO AKIBA (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 51-64.

This paper presents Japanese space activities with emphasis on aspects from the past two years. Introductory remarks outline the structure of space-related organizations and the basic principle for Japanese space activities. Among the scientific activities, the highlights in 1984-1986 are the launches of two spacecraft 'Sakigake' and 'Suisei' by M-3SII for Halley's comet exploration. In the field of practical applications, a meteorological satellite GMS-3 and a broadcasting satellite BS-2b were launched. The launch series includes the first launch of the H-I vehicle, which is characterized by the use of a cryogenic propellant for the second stage. In addition, the Space Activities Commission has approved two big projects: the development of the H-II launch vehicle and the participation to phase B activities in the U.S. Space Station program. Besides those prominent topics, major authorized programs are reviewed according to the newly revised space programs by the Space Activities Commission. Author

A87-32334

PREDICTION OF RANDOM VIBRATIONAL RESPONSES OF A LARGE SPACECRAFT IN ACOUSTIC ENVIRONMENT BY BLPF METHOD

HIDEHIKO MITSUMA (National Space Development Agency of Japan, Tokyo), SHOJI MAEKAWA, TORU ITO (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan), TOSHIAKI TAKAHASHI, YUJI KUBOTA (Toshiba Corp., Kawasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 449-454.

The prediction of the random responses of a large model spacecraft consisting of honeycomb sandwich panels and component mass dummies to a reverberant acoustic field is studied using the Band-Limited Power Flow (BLPF) method. This method has the same characteristics as the Statistical Energy Method (SEM) in the high frequency domain and is applicable to prediction in the low frequency domain. The predictive results are compared with experimental ones, and good agreement is found. It is concluded that the BLPF method is effective for random response prediction for spacecraft. C.D.

A87-32335

STRUCTURAL DESIGN AND COMPONENT TESTS OF LARGE GEOSTATIONARY SATELLITE BUS

HIDEHIDO MITSUMA, KUNIO NAKAMARU (National Space Development Agency of Japan, Tokyo), MASATAKA YAMAMOTO, KAZUMI OKUDA, and RYOICHI IMAI (National Space Development Agency of Japan, Tsukuba Space Center, Sakura) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 455-464.

This paper presents the results of the structural design and major component tests of the Large Geostationary Satellite Bus for the application satellites in the 1990s. The satellite main structure is composed of a panel assembly. The mission, bus, and AKE tank support structures of the satellite are modularized. Author

A87-32339

MODEL STUDY OF SIMPLEX MASTS

MICHIHIRO NATORI, MASAMORI SAKAMAKI, KORYO MIURA (Tokyo, University, Japan), KAKUMA OKAZAKI (Japan Aircraft Manufacturing Co., Ltd., Yokohama, Japan), and MASAKI TABATA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 489-496. refs

Large deformation properties of longerons and spacers of a coilable lattice mast for space applications are investigated. Some small models for laboratory experiments are manufactured and tested to get a fundamental understanding of the mechanism of a coilable lattice mast. Deformation patterns of a mast at each deployment stage are clearly shown, and the effects of material stiffness are also investigated. Author

A87-32341

DEPLOYABLE SURFACE TRUSS CONCEPTS AND TWO-DIMENSIONAL ADAPTIVE STRUCTURES

MICHIHIRO NATORI, KORYO MIURA (Tokyo, University, Japan), and HIROSHI FURUYA (Nagoya University, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 503-508. refs

Various conceptual considerations for both flat and curved deployable truss structures based on the collapsible transformations of polyhedral truss elements are presented from the viewpoint of geometry. Various deployable octet elements are investigated for systematic interpretations of deployable surface truss structures. The new possibility for two-dimensional adaptive structures with controllable geometry is also studied. Author

A87-32346

ENHANCEMENT OF SOLAR ABSORPTANCE DEGRADATION DUE TO CONTAMINATION OF SOLAR RADIATOR PANELS IN GEOSYNCHRONOUS ORBIT - CORRELATION OF FLIGHT DATA AND LABORATORY MEASUREMENTS

FRANCOIS LEVADOU, KEITH DERBYSHIRE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands), and ALAIN PAILLOUS (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 535-542. refs

The results of contamination/degradation tests and of a preliminary analysis of 2.5 years of operation of the Thermal Housekeeping Package (THP) aboard ECS-1, ESA's telecommunications satellite, are presented. Tests for UV and particle irradiation performed before the launch of ESA's Orbital Test Satellite (OTS), a forerunner of ECS-1, are briefly reviewed, and the irradiation and housekeeping tests undertaken after the OTS degradation analysis are discussed. The analysis of the degradation/contamination of the Optical Surface Reflector (OSR) and the ECS-1 is addressed. An enhancement of solar absorptance degradation due to contamination of OSR was clearly demonstrated by ground tests. C.D.

A87-32368

THERMAL VERIFICATION METHOD FOR LARGE SIZED SPACECRAFT

SATOSHI HAYASHIGUCHI, TATSUSABURO NAKAMURA (Kawasaki Heavy Industries, Ltd., Technical Institute, Akashi, Japan), AKIRA OHNISHI, and TOMONAO HAYASHI (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 697-702.

Space exploration in recent years has made possible the transport of a large payload with a large-sized vehicle, motivated by the advent of the Shuttle, which is encouraging the use of space for a host of new activities. As it becomes difficult to make a thermal balance test on the full scale necessary for thermal design with the enlargement of spacecraft, thermal balance test by a divided module is preferable and an experiment was conducted to develop this method. The modular test method divides a spacecraft into plural modules and makes a thermal balance test for each module, to evaluate the thermal design of a full-scale spacecraft. It arises in this method that a part of each divided module makes another heat exchange between its divided face and the chamber shroud. To solve this, a method of simulating the quantity of radiative heat exchange between each module by means of an infrared panel was adopted. In order to confirm the propriety of this modular test method, a thermal balance test using a simple box-shaped model was made, and good agreement was attained between the estimated temperature of the full-scale model obtained from the modular test method and the measured temperature of the full-scale model. Author

A87-32370

DEVELOPMENT OF FLUID LOOP SYSTEM FOR SPACECRAFT

MASAO FURUKAWA, YASUO NAKAMURA, RYOUICHI IMAI (National Space Development Agency of Japan, Sakura), TAKAHIRO KOMATSU, KIYOSHI TANAKA (NEC Corp., Yokohama, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 711-718.

This paper describes experimental results on the stability of temperature control for a single-phase fluid loop system being developed for possible use of a large geostationary satellite and a free-flyer. The developed model has 200 W of heat removal capacity and a weight of 20 Kg. As a result of temperature control via a bypass valve, the temperature of the cold plates arranged in series can be controlled within + or 3.0 C, and, in case of cold plates arranged in parallel, control is within + or - 3.5 C. Author

A87-32388
LABORATORY SIMULATION OF PLASMA INTERACTION WITH HIGH VOLTAGE SOLAR ARRAY
HARUHISA FUJII, YOSHIKAZU SHIBUYA (Mitsubishi Electric Corp., Amagasaki, Japan), TOSHIO ABE, KOICHI UCHI, RITAROH KASAI (Mitsubishi Electric Corp., Kamakura, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 825-830. refs

The interactions of solar arrays operating at a high voltage with dense plasma are investigated. Glass-covered aluminum plates simulating the solar arrays were subjected to dc potentials in a plasma-filled space chamber. When negative voltage was applied, arcing discharge occurred at the voltage less than 1000 V. The breakdown voltage decreased with increasing plasma density. The existence of the insulating cover glasses is found to lower the discharge voltage. In the case of positive polarity, however, no discharge occurred at the potential up to 1000 V. Author

A87-32456
DEVELOPMENT OF CARBON DIOXIDE REMOVAL SYSTEM - EXPERIMENTAL STUDY OF SOLID AMINES
KIYOSHI HIGUCHI (National Space Development Agency of Japan, Tokyo), SHUJI KANDA, HIROYUKI MATSUMURA, HIROAKI FUJIMORI, TAKATOSHI SHOJI (Kawasaki Heavy Industries, Ltd., Kobe, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1343-1348. Research supported by the National Space Development Agency of Japan. refs

This paper describes the carbon dioxide removal system in the Environmental Control and Life Support System for the Japanese Experiment Module of the Space Station. A solid amine, carbon dioxide removal substrate is under development at present to replace the consumptive adsorbent (LiOH). It is characterized by a regenerative agent which makes it possible to adsorb and desorb repeatedly. The other systems such as the electrochemical depolarized carbon dioxide concentration system and molecular sieves carbon dioxide removal system are also being developed. Author

A87-32475
SYSTEM AND OPERATION ANALYSES OF OTV NETWORK - A NEW SPACE TRANSPORTATION CONCEPT
TORU TANABE (Tokyo, University, Japan), SINICHI NAKASUKA, and TAKANORI IWATA IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1475-1480. refs

A space transportation system concept, OTV Network, is proposed, integrating space-based unmanned reusable OTVs and a set of fuel stations on earth orbits. The ability to enhance single OTV capability, the smallness of the expendable part, and the ability to separately launch OTVs and fuel supplies, increase flexibility and cost effectiveness. A new scheduler is also proposed which adopts a built-in simulator to cope with the many parameters to be set in the scheduling process. Off-nominal situations including emergent missions and OTV failures are also discussed. R.R.

A87-32507
OBSERVATION OF PRECIPITATION FROM SPACE BY THE WEATHER RADAR
KENICHI OKAMOTO, HARUNOBU MASUKO, SHIN YOSHIKADO (Ministry of Posts and Telecommunications, Radio Research Laboratory, Koganei, Japan), KENJI NAKAMURA, MASAHARU FUJITA (Ministry of Posts and Telecommunications, Radio Research Laboratory, Kashima, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1711-1720. refs

Progress to date on the development of a spaceborne active microwave weather radar by the Japan Radio Research Laboratory is summarized. The experiments have included joint operation with NASA of an airborne microwave rain scatterometer/radiometer functioning in the X- (9.86 GHz) and Ka-bands (34.45 GHz). Features and performance of the jointly operated system are described, including the scanning patterns explored, the principal characteristics of the radiometers, and data processing and display subsystems, which furnished quick-look color imagery for viewing within the aircraft. Results are reported from comparisons of the rainfall rate estimates obtained with a least-squares method with equivalent data from a ground-based C-band radar, and from measurements of rainfall over the ocean in terms of the attenuation coefficient. Preliminary specifications are provided for a spaceborne weather radar system. M.S.K.

A87-32529
SPACE STATION - OVERVIEW OF THE EUROPEAN CONCEPT OF COLUMBUS PROGRAMME STATUS AND CONTENT
R. MORY (ESA, Paris, France) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1891-1896.

Europe's role in the development of the Space Station is discussed. Consideration is given to the status of the Columbus program. The design and development of a pressurized module, polar platform, service vehicle, and resource module for the Space Station are examined. I.F.

A87-32530
SPACE STATION PROGRAM IN A LONG-RANGE SPACE DEVELOPMENT SCENARIO OF JAPAN
YOSHIAKI OHKAMI (National Aerospace Laboratory, Chofu, Japan) and MASAHIRO KAWASAKI (Science and Technology Agency, Research Coordination Bureau, Tokyo, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1905-1908.

An overview on the Japanese participation in the Space Station Program is presented in conjunction with long-range space development and utilization programs for the future. Based on the recognition that space utilization has eventually entered a new era, a large-scale and long-range scenario is depicted. Most important of all are the commercialization of space environment utilization and expansion of areas for human activities. This tends to support urgent development of space utilization technologies and manned space technologies, as well as development of efficient access means to the space environment. Participation in the International Space Station Program is one of the most appropriate options to realize the final goal. Author

A87-32531
STATUS OF JAPANESE EXPERIMENT MODULE DESIGN
Y. MORISHITA, M. SAITOU, K. HIGUCHI, and K. SHIRAKI (National Space Development Agency of Japan, Tokyo) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyn, AGNE Publishing, Inc., 1986, p. 1909-1913.

This paper describes the detailed definition and preliminary design (phase-B study) status of the Japanese Experiment Module (JEM), which is a Japanese contribution to the International Space Station (SS) program. The first half of the phase-B study of JEM was completed successfully in March 1986, and JEM primary functions and basic configuration have been established. Based upon the results of these efforts, official notification to conduct preliminary design of JEM was sent from the minister of Science and Technology Agency of Japan to the NASA administrator on March 10. Author

A87-32532
DEVELOPMENT OF EXPOSED DECK OF JAPANESE EXPERIMENT MODULE
KUNIAKI SHIRAKI, YOSHINORI YOSHIMURA (National Space Development Agency of Japan, Tokyo), JUNZO TANAKA, TOSHIHIKO OHTA, HITOSHI TEZUKA (Nissan Motor Co., Ltd., Aeronautical and Space Div., Tokyo, Japan) et al. IN: International

Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1915-1919.

Results are presented from a baseline trade-off study on sizing and concepts for the exposed structure for the Japanese experiment module (JEM) to be attached to the Space Station. The multipurpose facility will be approximately 3.3 x 1.4 x 2 m in size and will be carried into orbit on the Shuttle. The device will accommodate payload changeouts by the RMS and is to have a lifetime of 10 yr. Structural design criteria to ensure a harmonious interface with the Space Station and Shuttle are summarized, noting that a frame structure is the leading candidate for the final configuration. Extensive use will be made of CFRP materials for high stiffness, strength, and good thermal expansion characteristics. M.S.K.

A87-32534

AN ENCLOSED HANGAR CONCEPT FOR LARGE SPACECRAFT SERVICING AT SPACE STATION

YOSHIAKI OHKAMI, KOHTARO MATSUMOTO, TAKASHI KIDA (National Aerospace Laboratory, Chofu, Japan), TAKASHI IIDA (Ministry of Posts and Telecommunications, Radio Research Laboratory, Koganei, Japan), and JIRO SAKAI (Ohbayashi Corp., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1939-1944. refs

Two configurations for a large inflatable enclosed-space pressurized hangar being designed as a Space Station element for the purpose of providing a working area for semi-EVA spacecraft servicing are discussed. The hangar will be large enough to enable crews to assemble, measure, and repair such large structures as a 10-m class antenna planned for the Large Antenna Assembly and Measurement Experiment to be performed at the Japanese Experiment Module at the Space Station. A brief feasibility study on the large structure, the skin materials, and the operations management is presented with emphasis placed on the maintenance of pressure and temperature and the volume of the required air, identifying some technology problems that need to be resolved. I.S.

A87-32535

SOLAR CONCENTRATOR SYSTEM FOR EXPERIMENTS IN THE SPACE STATION

YOSHIHIRO NAKAMURA, HISAO AZUMA (National Aerospace Laboratory, Chofu, Japan), KUNIHIKO KAWAKAMI, and TATSUYA HAMAGUCHI (Mitsubishi Electric Corp., Communication Equipment Works, Amagasaki, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1945-1950. refs

The results of a preliminary study of the solar concentrator system (SCS), which will be used for experiments aboard the Space Station, are presented. The SCS, scheduled for launch in 1994 after the Space Station will have been positioned in LEO, is designed to make it possible to conduct experiments in the fields of material science, life science, space technology, and space energy. The features of these experiments are described along with a design study of the SCS elements which will make it possible to perform these experiments, such as the solar flux concentrating device, the primary and secondary reflectors, the shutters, the optical systems, and the solar energy transmitting device. A deployable truss beam and a pointing mechanism will make it possible to place the SCS in a location away from the pressurized module and to orient it toward the sun during one half of each orbit. Design diagrams are included. I.S.

A87-32537

EURECA - A FIRST STEP TOWARDS THE SPACE STATION

ROBERT MORY (ESA, Paris, France) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1957-1963.

The European Retrievable Carrier (Eureca) is designed for Shuttle launch to LEO, self-boost to a 525 km orbit, 6-9 mos on-station, then return to LEO for Orbiter retrieval. Eureca will provide a long-duration undisturbed 0.00001 g environment, reusable hardware (up to five times), and high power and mass capability for the payload. The design includes the SPAS truss structure, the Spacelab cooling system, bubble memory and a modular attitude control system. Two 7 m solar arrays will furnish 1 kW continuous (1.5 kW peak) power backed up to NiCd batteries. Orbit transfer will be achieved with redundant hydrazine-fueled boosters, and data transmission is to be by relay through the Olympus satellite to ESOC headquarters. The progression of missions envisioned and scheduled for Eureca includes baseline experiments, microgravity research, astronomy, solar physics, and earth remote sensing. Eventually, the Eureca design will be used for coorbiting and noncoorbiting platforms as part of the Space Station system. M.S.K.

A87-32539

CONCEPT DESIGN AND COST ESTIMATION OF A FREE-FLYING SPACE PLATFORM

MAKOTO NAGATOMO (Tokyo, University, Japan) and TAKASHI NAKAJIMA (Hitachi, Ltd., Satellite Systems Dept., Yokohama, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1971-1976.

Preliminary studies have been made for a free-flyer type of general-purpose facility to be released from and retrieved by the Space Shuttle. A reference model of the free-flying facility is the SFU, which accommondates payloads in six boxes called Payload Units and provides them with electrical power, thermal control, and data-management services. A Payload Unit is capable of installing payload with the maximum mass of 200 kg and supplying an average electrical power of 160 W. Two types of standard missions are considered. One is the STS-tended mission, and the other is the automated mission. A mission model for material processing consists of four flights: two STS-tended and two 3-month automated missions. A cost model for the reference model has been developed and used to estimate costs for experiments included in this mission model. The result shows that, since the STS operation is a dominant portion of mission operation costs, the cost-benefit approach is most important for experiment planning. Author

A87-32540

PAYLOAD BOOMERANG TECHNOLOGY FOR SPACE EXPERIMENTS AT VERY LOW GRAVITY LEVEL

AKIRA ONJI, YASUTOSHI INOUE, SHIGEAKI NOMURA, TAKASHI KIDA, and SHOICHI TSUDA (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1977-1982.

The payload boomerang satellite (PBS) is proposed for 10 hr g-jitter free microgravity experiments from a Space Station base. The PBS would be launched from the vicinity of the Station and would follow a passive trajectory to return to the Station. The spacecraft would have an aerodynamic umbrella for passive drag to control the trajectory relative the Station. Analytical models are presented for precise control of the trajectory. The models account for solar wind effects, aerodynamic effects and the effects of the solar panels on the Space Station orbit, and yield the launch velocity, recovery velocity and the range of the trajectories. A second-order analysis carried out with the model would yield 4 m accuracy for a 4 hr mission, and efforts are under way to perform a third order analysis which provides 1 m accuracy for a 10 hr mission. The PBS could also be used for performing experiments which will release gases which cannot be tolerated near the Space Station. M.S.K.

A87-32541

AUTONOMOUS DECENTRALIZED SYSTEM CONCEPT FOR SPACE STATION

TOSHIYUKI TANAKA, KUMIKO TAKIKAWA, AKIRA ASHIDA, SATOSHI MOHRI (Hitachi, Ltd., Space Systems Div., Yokohama, Japan), KINJI MORI (Hitachi, Ltd., Systems Development Laboratory, Kawasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1983-1988.

The Autonomous Decentralized System (ADS) is described for the Space Station data management and control system. ADS is configured to satisfy the fault tolerance, modularity, extensibility, and maintainability requirements of the Station. The concept is based on the design of living beings, which always have faulty parts, change constantly, and accomplish objectives. The changes are between operation, maintenance, and growth. ADS integrates autnomous subsystems which coordinate their activities with other subsystems if other subsystems fail. No priority is given any information in the data management system. The data flow is outward successively through every point in the system. Subsystems select data of interest, which requires the system to be semantics-, rather than syntax-based. Implementation of the concept in an autonomous decentralized loop is described, including the use of autnomous multimicrocomputers to enhance the reliability and flexibility of the system. M.S.K.

A87-32542

JAPANESE EXPERIMENT MODULE DATA MANAGEMENT AND COMMUNICATION SYSTEM

ISAO IIZUKA (National Space Development Agency of Japan, Tokyo), HARUMITSU YAMAMOTO, MINORU HARADA, IWAO EGUCHI, MASAMI TAKAHASHI (NEC Corp., Yokohama, Japan) et al. IN: International Symposium on Space technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1989-1994.

The data management and communications system (DMCS) for the Japanese experiment module (JEM) being developed for the Space Station is described. Data generated by JEM experiments will be transmitted via TDRS (primary link) to the NASDA Operation Control Center. The DMSC will provide data processing, test and graphics handling, schedule planning support, and data display and facilitate subsystems, payloads, emergency operations, status, and diagnostics and healthchecks management. The ground segment includes a mainframe, mass storage, a workstation, and a LAN, with the capability of receiving and manipulating data from the JEM, the Space Station, and the payload. Audio and alert functions are also included. The DMCS will be connected to the interior of the module with through-bulkhead optical fibers.

M.S.K.

A87-32546

A MASTER-SLAVE MANIPULATOR SYSTEM FOR SPACE USE

Y. TODA, K. MACHIDA, T. IWATA, K. NAKAYAMA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Sakura, Japan), J. NAKAGAWA (Mitsubishi Electric Corp., Kamakura, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2023-2028.

Design principles are defined for master-slave robotic manipulator systems (MRMS) for space applications, and tests of prototype embodiments of the principles are described. MRMS systems have a main arm and several slave arms, each with an independent control system, a data transmit rate of 300 kbps and a RS-422 serial port communication link. The console controller or the master arm end effector transmit position coordinates which are followed by the slave arms. The logic employed in determining the master manipulator position, path and torque and transmitting and converting the signals to slave arms and their effectors is outlined. Features of scale model master and slave MRMS are delineated, noting that controllers for both units employed MC68000 chips for high processing speed and low power consumption, and optic fibers for data transmission. Data from tests of the prototype systems are discussed in terms of problems in the controller logic and the performance in vacuum and atmospheric conditions.

M.S.K.

A87-32547

DEVELOPMENT OF SENSORS FOR REMOTE MANIPULATOR SYSTEM OF JAPANESE EXPERIMENT MODULE

NAOYA EZAWA, NAOKI NOGUCHI, and HIROMI AJIMA (Hitachi, Ltd., Space Systems Div., Yokohama, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2029-2034.

The JEM (Japanese experiment module) is to be supported in service by small and large remote manipulator systems, each with six degrees of freedom. Rotary encoders that will be mounted at the axis of each joint actuator to measure angular velocity are described, along with laser spot proximity sensors at the top of the gripper. The small arm will be controlled by force-feedback bilateral master-slave control and will have a six-axis force sensor between small fine arm and the gripper to monitor forces and moments on the arm. The arms will move in response to human movements of a master arm within the pressurized module. A detailed discussion is presented of the six axis force sensor which will provide feedback to the master arm controller. Finally, design and development problems still to be overcome are identified.

Author

A87-32655

AN ASSESSMENT OF RECENT ADVANCES IN MODELING AND CONTROL DESIGN OF SPACE STRUCTURES UNDER UNCERTAINTY

HAGOP V. PANOSSIAN (HR Textron, Inc., Valencia, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p. refs
(SAE PAPER 861818)

Uncertainty due to modeling approximations, random noise and tolerances in components, parametric and other errors in space structure modeling and control design create the need for stochastic representations. A short survey of different approaches to modeling of large flexible space structures under uncertainty is presented in the present article. Advantages and disadvantages of various modeling procedures for analysis and control design are briefly discussed and a novel approach is presented that incorporates statistical information in the best available mathematical model, and thus generates a realistic stochastic model for the structure. Moreover, difficulties relative to modeling, testing, validation, and verification in space structures are underlined and discussed. Author

A87-32801

GRAVITY-GRADIENT STABILIZATION OF THE SALYUT 6-SOYUZ ORBITAL COMPLEX

G. M. GRECHKO, V. A. SARYCHEV, V. P. LEGOSTAEV, V. V. SAZONOV, and I. N. GANSVIND (Kosmicheskie Issledovaniia, vol. 23, Sept.-Oct. 1985, p. 659-675) Cosmic Research (ISSN 0010-9525), vol. 23, no. 5, March 1986, p. 515-527. Translation. refs

A study is reported that uses the equations of motions of Sarychev and Sazonov (1981, 1985) for processing the measurements of several motion parameters obtained by cosmonaut Grechko aboard the orbital complex Salyut 6 and Soyuz spacecraft. Three series of measurements were made, two related to motion of the satellite under conditions of gravity-gradient stabilization and the other related to unstabilized motion. The purpose was to show that microaccelerations acting onboard the satellite are minimal under conditions of gravity-gradient stabilization. By using different methods to process these measurements, several real motions of the satellite were reconstructed and the satellite aerodynamic parameters were determined. D.H.

A87-32814

CONTRIBUTION OF THE GERMAN DEMOCRATIC REPUBLIC (EAST GERMANY) TO THE 'INTERCOSMOS' PROGRAM OF STUDY OF MATERIALS IN SPACE ABOARD THE ORBITING STATION SALYUT 6

J. BARTHEL and R. KUHL (Kosmicheskie Issledovaniia, vol. 23, Sept.-Oct. 1985, p. 783-791) Cosmic Research (ISSN 0010-9525), vol. 23, no. 5, March 1986, p. 611-618. Translation. refs

Several international projects involving the space studies of materials in 1978 and 1980 are recounted. Project Berolina was a joint USSR-East German project with East German cosmonaut Sigmund Jena aboard the satellite Salyut-6. Subsequent tests (in Projects Halong and Imitator) also included Vietnamese scientists. Experiments described cover: growth of BiSb crystals, smelting of glass, transport of germanium in the gaseous phase, guided crystallization of PbTe, sublimation of PbTe, guided crystallization of BiSb, guided crystallization of BiSbTe, and measurement of temperature distribution in identical ground-based and space ovens. D.H.

A87-32815

INSTABILITY OF AN ELASTIC FILAMENT IN ORBIT AROUND A GRAVITATING CENTER

A. I. MOROZOV and A. M. FRIDMAN (AN SSSR, Astronomicheskii Sovet, Moscow, USSR) (Zhurnal Tekhnicheskoi Fiziki, vol. 56, June 1986, p. 1065-1074) Soviet Physics - Technical Physics (ISSN 0038-5662), vol. 31, June 1986, p. 623-628. Translation. refs

A general equation is described for the motion of a perfectly flexible heavy filament in an external force field; the result is used to derive equations for arbitrary small perturbations in the motion of a filament in orbit around a gravitating center. Analysis of these equations shows that there is a wide range of equilibrium parameters for which the amplitude of all modes with m not equal to 0 increases and the motion becomes unstable. The instability stems from the presence of an elastic force, which causes the perturbed parts of the filament moving along orbits of unequal radius to revolve at the same angular frequency, so that the part of the filament farthest from the gravitating center is accelerated and moves farther away, while the inner portion moves closer to the gravitating center. This stretches the filament further, the elastic force increases, and the system becomes unstable. The results also apply to sufficiently flexible extended (but not necessarily closed) elastic objects that are oriented along the orbit. Two examples are considered: a metal filament in near space, and elongated ice 'needles' in Saturn's rings. The effective time for instability to develop is estimated. In the first case it is comparable to the time for one orbital revolution around the earth, while in the second case it is roughly equal to five orbital periods around Saturn. It is suggested that a computer-controlled feedback and servo system might be used to stabilize the motion. Author

A87-32819

CRITICAL LENGTH FOR STABLE ELONGATED ORBITING STRUCTURES

N. N. GORKAVYI, A. I. MOROZOV, and A. M. FRIDMAN (AN SSSR, Astronomicheskii Sovet, Moscow, USSR) (Zhurnal Tekhnicheskoi Fiziki, vol. 56, June 1986, p. 1210-1213) Soviet Physics - Technical Physics (ISSN 0038-5662), vol. 31, June 1986, p. 711-713. Translation. refs

The stabilizing effects of rigidity combined with tension are analyzed and the critical length for a stable section of rod lying tangent to the orbit are calculated. An example of elastic Euler instability for three-dimensional orbiting objects is provided. It is shown that, in large orbiting systems, the lengths of the rods tangent to the orbit and perpendicular to the orbital plane must satisfy certain conditions if they are to be stable. The precise form of these conditions depends on both the rigidity and tension on the rods. K.K.

A87-33867#

ADAPTIVE PLANAR TRUSS STRUCTURES AND THEIR VIBRATION CHARACTERISTICS

MICHIHIRO NATORI (Tokyo, University, Japan), KAZUO IWASAKI (National Aerospace Laboratory, Chofu, Japan), and FUMIHIRO KUWAO (Toshiba Corp., Aerospace Equipment Div., Kawasaki, Japan) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 143-151. refs
(AIAA PAPER 87-0743)

The structural concept of adaptive planar space truss structures is evaluated from the viewpoints of both geometrical adaptivity and dynamic characteristics. Some geometrical properties of a function model are also presented to demonstrate the effectiveness of the concept. Author

A87-34047

ON THE DYNAMICAL STABILITY OF THE SPACE 'MONORAIL'

S. BERGAMASCHI and D. MANNI (Padova, Universita, Padua, Italy) IN: International Conference on Nonlinear Mechanics, Shanghai, People's Republic of China, Oct. 28-31, 1985, Proceedings . Beijing, Science Press, 1985, p. 1165-1170. refs

The dynamical stability of 'monorail' tethered-satellite/elevator configurations being studied for the Space Station is investigated analytically, treating the end platforms and elevator as point masses, neglecting tether elasticity, and taking the Coriolis force and the complex gravitational field into account in analyzing the orbital-plane motion of the system. A mathematical model is constructed; the equations of motion are derived; and results obtained by numerical integration for platform masses 100,000 and 10,000 kg, elevator mass 5000 kg, and a 10-km-long 6-mm-diameter 4070-kg-mass tether are presented in graphs and briefly characterized. T.K.

A87-34207

CHOICE OF THE OPTIMAL ANGULAR POSITION OF A SPACECRAFT IN THE CONSTANT-SOLAR-ORIENTATION FLIGHT SEGMENT [VYBOR OPTIMAL'NOGO UGLOVOGO POLOZHENIIA KOSMICHESKOGO APPARATA NA UCHASTKE POSTOIANNOI SOLNECHNOI ORIENTATSII]

A. M. IANSHIN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 25, Jan.-Feb. 1987, p. 23-29. In Russian.

The orientation which assures minimum angular momentum due to gravitational and magnetic disturbances is determined for a typical spacecraft with solar panels (e.g., Soyuz or Mir). These disturbances are assumed to act on the spacecraft in an arbitrary unshaded orbit for maximum illumination of the solar panels. Attention is given to cases when the panels are fixed rigidly to the spacecraft and rotate with respect to a single axis. B.J.

A87-34208

OPTIMIZATION OF A PROGRAM OF EXPERIMENTS IN CONNECTION WITH THE OPERATIONAL PLANNING OF STUDIES CARRIED OUT WITH A SPACECRAFT [OPTIMIZATSIIA PROGRAMMY EKSPERIMENTOV PRI OPERATIVNOM PLANIROVANII ISSLEDOVANII, VYPOLNIAEMYKH S KA]

M. IU. BELIAEV and D. N. RULEV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 25, Jan.-Feb. 1987, p. 30-36. In Russian. refs

An approach to the optimal planning of experiments for the Salyut orbital station is described. The problem of operational experiment planning is reduced to an integer problem of linear programming. A set of programs for the BESM-6 computer has been developed for implementing the proposed method. The remote sensing of earth resources is considered as an example. B.J.

A87-34345

SHAPE CONTROL OF THE DIRECTIONAL PATTERN IN A MICROWAVE-BEAM POWER TRANSMISSION CHANNEL [UPRAVLENIE FORMOI DIAGRAMMY NAPRAVLENNOSTI V TRAKTE PEREDACHI ENERGII SVCH-PUCHKOM]

V. A. VANKE, S. K. LESOTA, and A. V. RACHNIKOV Radiotekhnika (ISSN 0033-8486), Jan. 1987, p. 70-73. In Russian.

It is demonstrated that it is possible to control the position of the field-intensity peak in the highly efficient microwave power transmission channel in a satellite solar power system. A channel having a directional pattern with an intensity dip on the beam axis is characterized by a high utilization coefficient (up to 0.56) of the receiving antenna and high levels of transmitted power. High values of channel efficiency (greater than 90 percent) are observed for values of the wave parameter tau greater than 3. B.J.

A87-34594

INTERNATIONAL COOPERATION IN SPACE

CRAIG COVAULT Commercial Space (ISSN 8756-4831), vol. 2, no. 4, Winter 1987, p. 16-19.

High costs and potential benefits of space activities are beginning a new era of global partnerships, with international space competition remaining important but gradually giving way to international cooperation. French Spot Earth resources satellite images are being marketed worldwide, the European Ariane booster has a 50 percent share of the world launch market, and the People's Republic of China is attracting international payloads for launch from its Xichang site. International participation on spaceflights is increasing, both on the Soviet Soyuz, Salyut and Mir spacecraft and on the U.S. Shuttles. The international Halley armada is another example of global cooperation. The international space picture is changing because of a new technologies in many nations, and the involvement of more countries (India, China, Japan, the Europeans). Five UN space treaties are in force, and a high degree of space cooperation for the 1990's seems likely. D.H.

A87-34595

ADVANCES BY THE SOVIET UNION IN SPACE COOPERATION AND COMMERCIAL MARKETING MADE 1986 A LANDMARK YEAR

JEFFREY M. LENOROVITZ Commercial Space (ISSN 8756-4831), vol. 2, no. 4, Winter 1987, p. 20-22.

A review is presented of the Soviet Union's new campaign for openness as it applies to planned space missions, new cooperation in space, and commercial marketing moves made public during 1986. It was exemplified when the head of the Soviet's Space Research Institute addressed an audience in the Sistine Chapel in 1986 giving detailed findings of the two Vega spacecraft from their encounter with Halley's comet. The Soviet Union is planning a Mars/Phobos mission in 1988, using two spacecraft on Proton launch vehicles. Other missions in the planning phase include Vesta flights to Mars and asteroid/comet targets in the 1990s and a lunar polar orbiter; the Vesta mission was proposed by France as one that could be conducted in cooperation with ESA. Solar-terrestrial missions - Interbol, Prognoz, Relicht 2 - are mentioned. Cooperative space science opportunities are being offered aboard Mir - a large modular manned space station operational in 1987. Commercially, the Soviets are prepared to orbit the Gorizont satellite, with six 6/4-GHz transponders, one 14/11-GHz transponder, and a 1.6/1.5-GHz transponder, and lease its communications capacity to a commercial user. Proton launch vehicle services for communications satellites are being offered at the rate of $24 millin per metric ton ($43 million for two tons), payable in Swiss francs. D.H.

A87-34874

MECHANICAL DESIGN OF THE EUROSTAR PLATFORM

K. HECKS (British Aerospace, PLC, Space and Communications Div., Stevenage, England) British Interplanetary Society, Journal (Space Chronicle) (ISSN 0007-084X), vol. 40, March 1987, p. 133-139.

Eurostar is a Communications S/c Platform developed by British Aerospace and Matra. It is designed to be compatible with Ariane 4/SPELDA and STS/PAM and usable for a range of possible missions. This paper discusses the mechanical design of the platform. This includes the overall configuration, the use of a 4-tank Combined Propulsion Subsystem, the Structure with CFRP central thrust tube, the Solar Array Drive and provisions for the Solar Array, and the Thermal Control.

A87-35076#

DEVELOPMENT OF HARMONIC DRIVE ACTUATOR FOR SPACE MANIPULATOR

TOSHIAKI IWATA, KAZUO MACHIDA, and YOSHITSUGU TODA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 395, 1986, p. 652-660. In Japanese, with abstract in English. refs

This paper presents the development of a harmonic drive actuator which features vacuum environment durability and the light-weight for a 1-m class space manipulator. A tribological study of bearings and gears is carried out experimentally. Some candidate materials and lubricants are tested in a vacuum chamber, and the wear properties are investigated. The ball bearing with MoS2-sputtered ball and race and a PTFE composite retainer had excellent characteristics and lifetime. An operation lifetime over 1,000 hours was attained for the harmonic gear by employing a nitrided steel spline and a PFPE grease. An actuator with a high torque/weight ratio, which was integrated with a rare-earth brushless servo motor, an optical encoder, drive electronics, and a harmonic gear compactly, was developed. Author

A87-35077#

A STUDY ON SINGULARITY OF SINGLE GIMBAL CMG SYSTEMS

HARUHISA KUROKAWA and NOBUYUKI YAJIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 395, 1986, p. 661-666. In Japanese, with abstract in English. refs

A single gimbal CMG system is a promising candidate for an actuator of attitude control systems for large space structures. One of its problems is the existence of singular states. Various steering laws assume redundancy in the system and avoid singular states by maximizing a certain criterion function value by a gradient method. But it is not theoretically clear whether these steering laws can actually avoid all singular states. In this paper, a quadratic form is defined for each singular state, which enables to classify singular states into three types. In the vicinity of two types of singular states, escape from the vicinity is not guaranteed locally. Also it is difficult to guarantee that the system does not go into the vicinity of any two types of singular points by using the gradient method only. Examples of the three types of singular states are shown for three configurations. Author

A87-35877

PROBLEMS OF MECHANICAL SYSTEM CONFIGURATION CONTROL [ZADACHI UPRAVLENIIA KONFIGURATSIEI MEKHANICHESKOI SISTEMY]

L. M. ARTIUSHIN (Kievskoe Vysshee Voennoe Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 23, Feb. 1987, p. 89-95. In Russian. refs

The problem of the configuration control of mechanical systems is analyzed using the method of inverse dynamics problems and a game theory approach. It is shown that the method of inverse dynamics problems makes it possible to resolve the difficulties associated with the determination of control law parameters on the basis of game theory. Control functions of the system elements are obtained analytically. For the algorithmic implementation of the control functions, a rigorous procedure is presented for determining the control law coefficients. V.L.

A87-37853

AUTOMATIC GENERATION OF STOCHASTICALLY DOMINANT FAILURE MODES FOR LARGE-SCALE STRUCTURES

YOSHISADA MUROTSU, SATOSHI MATSUZAKI, and HIROO OKADA (Osaka Prefecture, University, Sakai, Japan) JSME International Journal (ISSN 0913-185X), vol. 30, Feb. 1987, p. 234-241. refs

This paper proposes a branch-and-bound technique which generates stochastically dominant structural failure modes by using a lower bound of the complete failure path probability. Combinatorial properties of the failure paths are clarified and it is shown that there are many complete failure paths in a large-scale structure with a high degree of redundancy. Then, in order to reduce the number of computations, heuristic operations are applied to the branch-and-bound algorithm. Finally, the validity of the heuristic operations is demonstrated through numerical examples. Author

A87-37962

THE EUROPEAN SPACE PROGRAMME

REIMAR LUEST (ESA, Paris, France) Space Policy (ISSN 0265-9646), vol. 3, Feb. 1987, p. 2-4.

The current objectives of ESA are described. Consideration is given to the development of the Ariane 5 launcher, the Columbus program, and activities in the fields of space science, earth observations, telecommunications, and microgravity. Advances in the areas of in-oribt infrastructure and space transportation systems are examined; particular attention is given to Hermes and the Columbus program. The benefits provided by international cooperation in the exploration of space are discussed. I.F.

A87-37964

FLUNKING ON SPACE STATION COOPERATION?

WULF VON KRIES (DFVLR, Washington, DC) Space Policy (ISSN 0265-9646), vol. 3, Feb. 1987, p. 10-12.

The relationship between the U.S. and Europe concerning the development of the permanently manned Space Station is examined. The advantages of international cooperation in the construction of the Space Station are discussed. It is argued that shared rights and responsibilities for the Space Station between the U.S. and Europe are required for the Space Station development to be successful. I.F.

A87-37971

MIR IN ACTION

NEVILLE KIDGER Spaceflight (ISSN 0038-6340), vol. 29, April 1987, p. 136, 137.

The activities undertaken in the Soviet Mir manned-space-station program in early 1987 are described and illustrated with photographs. Consideration is given to the launch of Progress 27 on January 16 and the components of its astrophysics payload module (the ESA Sirene-2 high-pressure gas-scintillation counter, a Netherlands experiment including the TTM coded-mask imaging spectrometer, a West German scintillation spectrometer for 15-250-keV X-ray sources, and the Soviet Pulsar X-1 sensor for X and gamma rays up to 800 keV). Also discussed are the preparation and launch (on February 5) of Soyuz TM-2 with two cosmonauts aboard, Soyuz-Mir docking on February 8, orbit adjustments on February 11 (using the Progress engines), the apparent failure of the Luch GEO relay spacecraft, and plans for a visit to Mir by three cosmonauts in July 1987. T.K.

A87-38443

THE SIGNE II GAMMA-RAY BURST EXPERIMENT ABOARD THE PROGNOZ 9 SATELLITE

M. BOER, K. HURLEY, M. NIEL, G. VEDRENNE (Centre d'Etude Spatiale des Rayonnements, Toulouse, France), A. KUZNETSOV (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR) et al. (COSPAR, Plenary Meeting, 26th, Topical Meeting on Gamma-Ray Astronomy, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 4, 1986, p. 97-102. refs

The Signe II M p-9 experiment operated aboard the Prognoz 9 satellite for 8 months in 1983-1984. It was designed to study cosmic and solar gamma ray bursts in the 40-8000 keV energy range, using two 178 sq cm NaI scintillators. A description of the mission and the experiment are presented. The experiment discovered what appears to be a unique new transient source, and has also provided evidence for rapid spectral variability at MeV energies in a gamma burst spectrum. Author

A87-38727

SYSTEM ASPECTS OF COLUMBUS THERMAL CONTROL

U. LAUX, K. BECKMANN, and R. LAWSON (MBB-ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 247-257.
(SAE PAPER 860938)

The Columbus spacecraft's thermal control system must cope with numerous different mission phases, including Space Shuttle transportation to orbit, in-orbit assembly, payload operation, payload servicing, payload dormancy, and even contingency operations that have yet to be defined in detail. Attention is presently given to a thermal control system design approach that stresses encompassing commonality at all levels for fluid types and their flow regimes, as well as for a pressurized module cooling loop design. These thermal control system determinations are then applied to Orbit Replaceable Unit design configurations. O.C.

A87-38728

INFRARED TEST TECHNIQUE VALIDATION ON THE OLYMPUS SATELLITE

P. MESSIDORO and E. COLIZZI (Aeritalia S.p.A., Turin, Italy) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 259-268. refs
(SAE PAPER 860939)

The sheer size of the Columbus spacecraft and the presence of heat pipes on both of its radiators have suggested the present use of a spacecraft thermal model to assess the feasibility of IR testing. Data have been thus obtained which are pertinent to thermal control system design and both thermal and mathematical modelling. Attention is given to the test apparatus employed, the power control system used, and the characteristics of such IR test elements as IR sources, flux requirement definitions, outer surface property measurements, and the correlation methods applied to the test results. O.C.

A87-38747

PHYSIOLOGICAL REQUIREMENTS AND PRESSURE CONTROL OF A SPACEPLANE

LOUIS LEMAIGNEN, CATHERINE FAGOT, and MARC WEIBEL (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 475-484. refs
(SAE PAPER 860965)

After a short presentation of the different functions of the Environmental Control and Life Support System (ECLSS), the paper shows the driving role of the atmosphere delivery and pressure control subsystem. The main physiological requirements of environmental control are presented: oxygen delivery, total pressure and total pressure variations, carbon dioxide concentration. The acceptable limits of the different parameters are discussed and a comparison is made with the operational requirements of existing space vehicles. From this analysis a selection is made for nominal, degraded and emergency modes. A safety philosophy is presented and application is made to different emergency situations. For emergency situations, the proposed solution is intermediate between the Orbiter choice and the Soyuz approach. A mathematical model of the vehicle's partial pressures is presented. This computer program is used to optimize the pressure management in the emergency modes and in transient conditions like EVA prebreathing and airlock operation. Author

A87-38748

COLUMBUS LIFE SUPPORT SYSTEM AND ITS TECHNOLOGY DEVELOPMENT

H. P. LEISEIFER, A. I. SKOOG, and H. PREISS (Dornier System GmbH, Friedrichshafen, West Germany) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 485-497. ESA-BMFT-supported research. refs
(SAE PAPER 860966)

The ESA's Columbus program element of the NASA Space Station employs a Pressurized Module (PM) whose Environmental Control and Life Support Subsystem (ECLSS) baseline is presently discussed for the case of PM attachment to the Space Station and in view of comparisons with the Spacelab ECLSS. A systems approach is used in these considerations, and technology readiness and development requirements are identified in light of hardware-related ECLSS design factors. Technology implementation goals are then formulated. The PM ECLSS undertakes atmospheric pressure and composition control, CO2 management, atmospheric contamination management, cabin temperature and humidity management, avionics and experiment cooling, fire detection and suppression, water and waste management, and power and thermal budgeting. O.C.

A87-39594#

EUROPE PREPARES FOR MANNED ORBITED OPERATIONS

RUDI G. REICHERT Dornier Post (English Edition) (ISSN 0012-5563), no. 1, 1987, p. 44-47.

Manned space operations proposed by ESA are discussed. The development of a space suit system is examined in terms of its applications and life support system requirements. Consideration is given to the fabrication of manned maneuvering equipment and special test facilities for evaluating new equipment, and an air lock design. I.F.

A87-39836

NON-INTRUSIVE TECHNIQUES FOR THERMAL MEASUREMENTS IN MICROGRAVITY FLUID SCIENCE EXPERIMENTS

R. MONTI and R. FORTEZZA (Napoli, Universita, Naples, Italy) (COSPAR, Plenary Meeting, 26th, Topical Meeting on Material Sciences in Space - IV, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 5, 1986, p. 69-80. Research supported by Montedel-Montecatini Edison Elettronica S.p.A.

Three nonintrusive techniques for thermal measurements in microgravity fluid dynamics are considered in the paper: liquid crystals tracers, thermographic system, and thin-foil fluxmeter. Liquid crystals have been employed both as tracers (for the evaluation of the flow field organization) and as point thermometers (for the temperature distribution). Liquid surface measurements are performed in closed and open cells. Heat fluxes measurements have been performed by thin-foil fluxmeters, and temperature by thermographic method. The laboratory experimentation substantiate the applicability of these techniques in fluid dynamics experimentation on space platforms. Author

A87-40339

LEGAL PROBLEMS CONCERNING MANNED SPACE FLIGHT [PRAVOVYE PROBLEMY POLETOV CHELOVEKA V KOSMOS]

E. G. VASILEVSKAIA, V. S. VERESHCHETIN, G. P. ZHUKOV, E. P. KAMENETSKAIA, and A. I. RUDEV Moscow, Izdatel'stvo Nauka, 1986, 224 p. In Russian. refs

A systematic analysis of legal problems concerning manned space flight is presented. Issues addressed include the legal sense of the concepts of manned spacecraft, astronaut, and spacecrew; jurisdiction over manned spacecraft and spacecrews; the law governing manned orbital stations; legal problems concerning human activity on the moon; international spacecrews; and legal aspects of crew safety. Consideration is also given to responsibility for human activity in space in the context of international law, the legal consequences of the privatization of space activity, and the prevention of space militarization. B.J.

A87-40342

K.E. TSIOLKOVSKII AND PROBLEMS IN THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY [K.E. TSIOLKOVSKII I PROBLEMY RAZVITIIA NAUKI I TEKHNIKI]

B. M. KEDROV, ED. and A. A. KOSMODEM'IANSKII, ED. Moscow, Izdatel'stvo Nauka, 1986, 192 p. In Russian. No individual items are abstracted in this volume.

Aspects of long-duration space flight are examined in the light of Tsiolkovskii's ideas. Particular consideration is given to advances in rocket and space technology, space-flight mechanics, and space industrialization. A number of biomedical problems connected with the prolonged stay of man in space are examined. Philosophical problems connected with space exploration are discussed along with Tsiolkovsii's theories about scientific prediction. B.J.

A87-40513#

THE SPACE STATION - USES AND USERS [DIE RAUMSTATION - NUTZEN UND NUTZER]

DIETRICH LEMKE (Max-Planck-Institut fuer Astronomie, Heidelberg, West Germany) Sterne und Weltraum (ISSN 0039-1263), vol. 26, April 1987, p. 202-205. In German.

The status of the Space Station (SS) program three years after its inception is reviewed from a European perspective, with emphasis on astronomy applications. Topics discussed include the ESA Columbus contribution to the SS (manned laboratory module, free-flying unmanned laboratory, polar platform, and Eureca multipurpose vehicle); the basic scientific research (with limited immediate economic return) to be undertaken; vibration problems for telescopes mounted on the main SS structure; the value of manned laboratories; the technological, political, and economic lessons of the Spacelab program for ESA; and proposals to increase European space independence. Concern is expressed that potential scientific SS users may have difficulty in obtaining funding and/or Spacelab prototype-testing opportunities for their experiments, due to the cost of the SS itself and the U.S. military, commercial, and SS-related demands on Shuttle space when flights resume. T.K.

A87-41219

THOUGHTS ON EUROPE'S FUTURE IN SPACE

HARRY O. RUPPE (Muenchen, Technische Universitaet, Munich, West Germany) Space Policy (ISSN 0265-9646), vol. 3, May 1987, p. 89-91.

ESA plans for the near term are reviewed from a technological perspective, with an emphasis on the Ariane 5, Hermes, and Columbus programs, and a number of specific criticisms and recommendations are presented. The development of Ariane 5L as a possible successor to the Ariane 5P, continuation of some versions of Ariane 4 for smaller single payloads, postponement of the current Hermes in favor of a simple space capsule, and more intensive study of transport from the Space Station to application orbits (such as polar orbits) are recommended. Current proposals for launch vehicles with air-breathing initial stages (Hotol, Saenger, TAV, etc.) are viewed with scepticism, pointing to a lack of adequate data on the performance, development schedules, critical technologies, costs, and facilities requirements of such vehicles. T.K.

A87-41429

COLUMBUS/SPACE STATION UNITED KINGDOM UTILISATION STUDY 1985/6 REPORT - EXECUTIVE SUMMARY

International Journal of Remote Sensing (ISSN 0143-1161), vol. 8, April 1987, p. 545-554.

The opportunities that participation in the Space Station and Columbus programs would provide for the user communities of the United Kingdom are examined. Strategies for participating in these programs and obtaining benefits are proposed. The conditions under which the United Kingdom would participate in the Columbus program are described. It is recommended that the UK be involved in the development of the Polar Platform, the space segment of the Columbus infrastructure, advanced sensor payloads, a national ground segment, R&D, and the establishment of a strong user community. Consideration is given to the education and training of people in space technology, and the financing of the project. It is noted that participation in the Columbus program will benefit operational activities such as meteorological and oceanographic forecasting, a wide range of commercial operations, and research in many areas such as earth science and astrophysics. I.F.

A87-41570

JAPANESE EXPERIMENT MODULE (JEM) PRELIMINARY DESIGN STATUS

M. SAITO, K. HIGUCHI, and K. SHIRAKI (National Space Development Agency of Japan, Tokyo) (IAF, International Astronautical Congress on Space: New Opportunities for all People, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, p. 47-53.

The first half of the present two-year study of the Japanese Experiment Module's (JEM) preliminary design has given attention to the definition of basic design requirements, major interface areas between JEM and the NASA Space Station core, and such general issues as the JEM configuration, basic development plan, and operations. The second half of the study will evaluate the technology development requirements of JEM elements' preliminary design, as well as engage in the preparation of schedules and requirements for the next two development stages. O.C.

A87-41678

SPACE STATION OPPORTUNITY FOR UK IN EARTH SENSING

JOHN PLEVIN and DAVID LYNN (NERC, Swindon, England) Spaceflight (ISSN 0038-6340), vol. 29, May 1987, p. 193-197.

A national UK program aimed at developing a polar platform preparatory program, a national sensor development program, data management facilities, and arrangements for operation and management of the polar platform in space is proposed. The need for a polar platform preparatory program in order to develop applications for the platform and to educate and train the users is discussed; the goals of this program are described. The role of the polar platform in remote sensing is examined. Consideration is given to the designing of the polar platform to meet user requirements, and the benefits the platform will provide to earth observation studies by industry, government, and science. I.F.

A87-41954

EFFECT OF CREW MOTIONS ON THE SPATIAL POSITION OF A SPACECRAFT [O VLIIANII DVIZHENIIA KOSMONAVTA NA PROSTRANSTVENNOE POLOZHENIE KOSMICHESKOGO KORABLIA]

G. R. SALIMOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Mar.-Apr. 1987, p. 20-26. In Russian. refs

Equations of motion for a spacecraft are obtained with allowance for the motions of the crew inside the spacecraft and on its outside surface. The spacecraft is modeled by a rigid body and the crew by a point mass; the motion of the crew is assumed to be known a priori. In particular cases, an analysis is made of the relationship between the angular velocity and system parameters. It is shown that when the crew moves at a constant relative velocity, the angular velocity of the spacecraft depends only on the final position of the crew. A class of possible trajectories is examined, and results of numerical calculations are presented. V.L.

A87-42296#

MODAL-SURVEY TESTING OF THE OLYMPUS SPACECRAFT

R. STEELS and D. BASTON (ESA, Communications Satellite Dept., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 10, no. 4, 1986, p. 363-371.

This paper describes the background to the introduction of a spacecraft modal-survey test in the development program for ESA's Olympus telecommunications satellite. It details the objectives of such tests, how the test was actually performed, and the use to which the test results have been put. A concluding section assesses the benefits that have accrued to the Olympus satellite program from the tests performed. Author

A87-42923

THE GAGARIN SCIENTIFIC LECTURES IN ASTRONAUTICS AND AVIATION. 1985 [GAGARINSKIE NAUCHNYE CHTENIIA PO KOSMONAVTIKE I AVIATSII. 1985 G.]

A. IU. ISHLINSKII Moscow, Izdatel'stvo Nauka, 1986, 240 p. In Russian. No individual items are abstracted in this volume.

Several of the presentations from the Gagarin lectures are presented in full, including reports on 25 years of activity at the Gagarin Cosmonaut Training Center, preliminary results from the 237-day mission on Salyut-7, and the Vega mission to Comet Halley. Finally, abstracts are presented for a large number of papers from various fields, including flight mechanics, flight simulation, spacecraft design, space manufacturing, and thermal and gasdynamic problems of space flight. B.J.

A87-43156

JAPAN'S SPACE DEVELOPMENT PROGRAMS FOR COMMUNICATIONS - AN OVERVIEW

TADAHISA MORI and TAKASHI IIDA (Ministry of Posts and Telecommunications, Tokyo, Japan) IEEE Journal on Selected Areas in Communications (ISSN 0733-8716), vol. SAC-5, May 1987, p. 624-629. refs

Japan now operates the communications satellite CS-2. A test communications satellite, CS-1, was launched in 1977, and CS-3 will be launched in 1988 as a successor to CS-2. In the area of mobile satellite communications development, Japan is proceeding with an experimental program, ETS-V/EMSS (Engineering Test Satellite-V/Experimental Mobile Satellite System), for which a satellite will be launched in 1987. A follow-up experimental ETS-VI program is planned and will be launched in 1992 as a 2000-kg weight class satellite. Japan has also begun an Experimental Platform Study as a step toward the Geostationary Communication Platform. This paper reviews and explains the scenario, activities, and objectives of satellite communications development in Japan. Author

A87-44683

SOLAR POWER SATELLITES [SOLNECHNYE KOSMICHESKIE ENERGOSTANTSII]

VLADIMIR ALEKSANDROV GRILIKHES Leningrad, Izdatel'stvo Nauka, 1986, 182 p. In Russian. refs

The current status of research on the solar power satellite (SPS) concept is reviewed. Particular consideration is given to the development of microwave power transmission systems and to alternative SPS designs (thermal and photoelectric). Problems connected with the development of SPS systems are considered; these include problems of construction and transportation as well as ecological, social, and economic problems. B.J.

A87-45257#

ARIANE TRANSFER VEHICLE (ATV) TO SUPPLY SPACE STATION

R. RAULT (Aerospatiale, Les Mureaux, France) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 9 p.
(AIAA PAPER 87-1862)

Ariane transfer vehicle mission description is described as well as ATV design, the propulsion subsystem (and others), performance, and development plan and cost assessment. Particular attention is given to the major results of a comprehensive study performed for the ESA within the Columbus studies program. It is noted that, as a fully autonomous system, ATV is not limited to use on Ariane 5. K.K.

A87-46121

DETERMINATION OF THE NATURAL FREQUENCIES OF THE LONGITUDINAL AND TORSIONAL VIBRATIONS OF TRUSS STRUCTURES WITH ATTACHED RIGID BODIES [OB OPREDELENII SOBSTVENNYKH CHASTOT PRODOL'NYKH I KRUTIL'NYKH KOLEBANII FERMENNYKH KONSTRUKTSII S PRISOEDINENNYMI TVERDYMI TELAMI]

S. V. KOZLOV and N. I. VOITKOV (AN USSR, Institut Mekhaniki, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 23, May 1987, p. 95-102. In Russian. refs

A method is presented for determining the effective elastic and inertial characteristics of a continuum idealized model of large truss structures with allowance for rigid connections between the rod elements. The method is applied to the analysis of the longitudinal and torsional vibrations of a truss structure consisting of beam members with attached massive bodies at the ends. Changes in the natural vibration frequencies of the structure are determined as a function of the attached masses. V.L.

A87-46872#

MIR - A SECOND SPUTNIK?

RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 25, July 1987, p. 24-27.

The efforts of the Soviets on the development of a large permanent space station complex for the 1990's are considered. The Mir space station has a transfer module with four side berthing ports to accommodate the Kosmos lab modules used for astrophysics, earth resource, material processing, and biology research; solar panels that provide 9-10 kW of electric power; an antenna that increases the time of contact with the flight control center; eight on-board computers; and improved living conditions. The transfer of the Mir crew to Salyut 7, and some of the experiments conducted on Salyut 7 and Mir are described. The need to establish a definite space policy in order for the U.S. to develop a Space Station is discussed. I.F.

A87-46945

COLUMBUS PRESSURIZED MODULES

ERNESTO VALLERANI (Aeritalia S.p.A., Settore Spazio, Turin, Italy) Space (ISSN 0267-954X), vol. 3, May-June 1987, p. 10-12, 14, 15.

The present status and prospects for the Columbus program are reviewed. The two modules of the Columbus program, the Pressurized Module and the Man-Tended Free Flyer, are discussed, including present design plans and operational issues. The primary structures of the modules and the environmental control and life support, thermal control system, electrical power distribution system, communications, and data management system for the modules are reviewed. The U.S. Defense Department's interest in the Space Station and its effects on the Columbus program are considered. C.D.

A87-47302

THE SOVIET SPACE SHUTTLE PROGRAMME

TONY LAWTON Spaceflight (ISSN 0038-6340), vol. 29, July 1987, p. 4-7.

The launch vehicles and hypersonic spaceplanes being developed by the Soviet Union are examined. Consideration is given to the Proton launch vehicle that has a lifting capability of 19.5 tons to LEO; the SL-X-16, a medium-lift launch vehicle with a payload capability of 15 tons; the SL-W shuttle; the SL-W heavy-lift launch vehicle; and the spaceplane, Kosmolyot I and II. The flight testing of the midgetlike hypersonic aircraft, referred to as Moshka, and a large spaceplane, Buran, which has the main engines located on the frame carrying the fuel tanks and boosters, are discussed. It is suggested that the space shuttle may be added to the Salyut and Mir in order to create a large space station complex. The first launch of the heavy lift launcher, Energia, is also discussed. Diagrams of the launch vehicles, Moshka, Buran shuttle, and a possible advanced space station configuration are presented. I.F.

A87-48157

THE PROBLEM OF RADIATION EXPOSURE IN THE SPACE STATION [DAS PROBLEM DER STRAHLENBELASTUNG IN DER RAUMSTATION]

H. BUECKER and G. REITZ (DFVLR, Institut fuer Flugmedizin, Cologne, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 504-512. In German. refs
(DGLR PAPER 86-175)

The radiation environment at the Space Station orbit is characterized, summarizing data obtained on Spacelab D1 and other earlier missions, and its implications for the design and use of the Space Station are considered. Consideration is given to the principal radiation sources (solar-wind and solar-flare protons, auroral protons and electrons, trapped protons and electrons, and Galactic cosmic rays); the frequency of South Atlantic Anomaly (SAA) crossings by the Space Station; the relative biological effectiveness of the different radiation types; linear-effective-transit spectra for space missions since Apollo 16; and D1 Biorack results. It is estimated that the 50-rem maximum annual dose recommended by the National Committee of Radiation Protection (1975) would be reached after 172 days on the Space Station, even if the SAA uncertainties, the effects of microgravity on radiation sensitivity, and solar flares are not taken into account. T.K.

A87-48578#

ESA'S FUTURE INTEGRATED SPACE DATA SYSTEM

CLAUDE HONVAULT (ESA, European Space Operations Centre, Darmstadt, West Germany) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 9 p.
(AIAA PAPER 87-2190)

The approach taken by the ESA to meet the challenge of the space data systems of the next decade is described. Objectives for the next 13 years include participation in cooperative programs as partners in the Space Station program and eventual European independence of the in-orbit infrastructure. The achievement of these objectives requires the establishment of standards for electronic data exchange and processing and the implementation of an integrated system design approach for the ground facilities. The proposed space data system consists of a data relay satellite system concept based on a decentralized system whereby the downlink channels can be directly accessed by user terminals in the broadcast area and the uplinkings authorized by a traffic management center. An overview is given of the present-day communications requirements of the Hermes spaceplane. K.K.

A87-48579#

JAPANESE SPACE INFORMATION SYSTEM OVERVIEW

K. MATSUMOTO (National Space Development Agency of Japan, Tokyo) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 8 p.
(AIAA PAPER 87-2191)

The space operations and data system (SODS) which will provide operational capabilities for the H-II rocket and space shuttle era is proposed. The SODS is to consist of a global communications network system, an operational control system, and an engineering support and information system. The capabilities of the SODS and the functions of its systems are described. The stages for the implementation of the system are discussed. Diagrams of the SODS are presented. I.F.

A87-48580#

JAPANESE CUSTOMER NEEDS FOR SPACE STATION

K. HIGUCHI, I. IIZUKA, and Y. FUJIWARA (National Space Development Agency of Japan, Tokyo) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 10 p.
(AIAA PAPER 87-2193)

Results from mission analysis in communications, the requirements of Japanese customers, and the Japanese Experiment Module Information System (JEMIS) are discussed. Mission objectives include: scientific observation, earth observation, communications, materials processing and production, life science, and technology development. The data exchange between the Japanese Experiment Module (JEM) and the ground was analyzed; it is determined that experimental, computer voice, video, and real and nonreal time data are required for the communications missions. A cosmic gamma ray burst, space energy, and test of sensor technologies experiments will be conducted to define the capacity of data transmissions. The JEMIS will provide payload operation support functions and increase JEM operation while retaining operating flexibility. The main elements of the information system, its functions, and JEMIS data transmission requirements are described. Diagrams of the JEMIS are presented. I.F.

A87-48581#

SCIENTIFIC USER REQUIREMENTS FOR MICROGRAVITY RESEARCH (EUROPEAN ASPECTS)

I. EGRY, G. OTTO, and B. FEURBACHER (DFVLR, Cologne, West Germany) AIAA and NASA, International Symposium on Space

Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 7 p. refs
(AIAA PAPER 87-2195)

The user requirements on the Columbus elements and their implications regarding telescience are discussed. Telescience experience gained during the D1 mission (fall of 1985) is described. A graph is presented which reveals the dramatic increase in utilization potential that Columbus offers compared to Spacelab or Eureca flights. It is noted that a huge ground infrastructure involving interconnected mission control centers, user support centers, and user operation centers will be necessary to fully exploit this opportunity. K.K.

A87-48585#

JAPANESE DATA RELAY SATELLITE SYSTEM

M. IKEUCHI, T. TANAKA, M. KAJII, H. AWAZAWA, T. DOURA (National Space Development Agency of Japan, Tokyo) et al. AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 9 p.
(AIAA PAPER 87-2199)

This paper describes one possible Japanese data relay satellite system concept for the Space Station era. The Data Relay and Tracking Satellite System (DRTSS) will provide S-band and Ka-band communication and tracking service for orbiting spacecraft with data rates up to 300 Mb/s. Mission objectives and analysis are discussed, and the related experimental ETS-VI program is also presented. Author

A87-48592#

ESA SOFTWARE ENGINEERING STANDARDS FOR FUTURE PROGRAMMES

C. MAZZA (ESA, European Space Operations Centre, Darmstadt, West Germany) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 7 p. refs
(AIAA PAPER 87-2207)

ESA has established since several years a board for software standardization which has developed and promoted the ESA Software Engineering Standards. These Standards have been in use now for 3 years on several software projects and subsequently reviewed. The last issue will constitute the baseline for software standards for all ESA future missions. The essential principles on which the standards are based are explained. ESA has also formulated a policy for the choice of programming languages for future projects and for the selection of a European Space Software Development Environment which will support the above standards and the selected languages. Author

A87-48595#

ANALYSIS AND IMPLEMENTATION OF AUTOMATION ASPECTS IN THE COLUMBUS AND HERMES END TO END SYSTEMS

M. SAINZ (Matra, S.A., Toulouse, France) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 6 p.
(AIAA PAPER 87-2210)

A profile is presented of European space operations with emphasis placed on new space programs, space infrastructure, constraints (operational, user, and program), and automation. Lessons learned from the Spot 1 satellite and Spacelab are also discussed. The areas of automation on-board Columbus and Hermes are contingency, configuration, and operations management as well as crew interface. Ground-based automation candidates are contingency management, telecommand generation, payload operations planning, and interaction. K.K.

A87-48596#

THE HARDWARE/SOFTWARE ARCHITECTURE OF THE COLUMBUS PRESSURIZED MODULE ELEMENT

G. C. CASSISA and L. SARLO (Aeritalia S.p.A., Gruppo Sistemi Spaziali, Turin, Italy) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 9 p.
(AIAA PAPER 87-2211)

Pressurized module (PM) functions and services relevant to the Columbus Information Management System (CIMS) are considered. Included are system level management, man machine interface, data distribution, check-out, and servicing support. The CIMS hierarchical organization is described as well. K.K.

A87-48605#

EVOLUTION OF DATA MANAGEMENT SYSTEMS FROM SPACELAB TO COLUMBUS

G. BRANDT and H. J. POSPIESZCZYK (MBB-Erno Raumfahrttechnik GmbH, Bremen, West Germany) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 8 p.
(AIAA PAPER 87-2227)

This paper describes the evolution of data management systems, starting with the generic Spacelab design and followed by its utilization during the missions FSLP, D1, and D-2 It describes the Eureca system and finally outlines the Columbus plans. It discusses the experience gained in particular from Spacelab development and mission preparation. An attempt is made to formulate the corresponding Columbus guidelines. Author

A87-49030

RADIATION PROTECTION PROBLEMS FOR THE SPACE STATION AND APPROACHES TO THEIR MITIGATION

H. BUECKER and R. FACIUS (DFVLR, Institut fuer Flugmedizin, Cologne, West Germany) (COSPAR and National Council on Radiation Protection and Measurements, Plenary Meeting, 26th, Topical Meeting and Workshop VII on Life Sciences and Space Research XXII/1/, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 11, 1986, p. 305-314. refs

This paper considers the radiation protection standards, the systems of dosimetric surveillance, and the possible methods of selective shielding for a space station. The problems that need to be investigated include the composition of the external radiation field and the variability in space and time in the conditions of the radiation field, the spacecraft shielding interaction, the effects of the depth-dose distribution, the unique HZE effects, the relative contribution of the separate radiation components to the total dose equivalent deposited in man's critical organs, and a possible contribution to radiation-effected damage by microgravity. The need of a radiation monitoring system and personnel dosimeters is emphasized. I.S.

A87-49967#

LIFE SUPPORT SUBSYSTEM CONCEPTS FOR BOTANICAL EXPERIMENTS OF LONG DURATION

H. LOESER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, West Germany) Intersociety Conference on Environmental Systems, 16th, San Diego, CA, July 14-16, 1986, Paper. 18 p. refs
(MBB-UR-E-907-86-PUB)

The likely requirements (in terms of air temperature, relative humidity, composition of atmosphere, and fluids control) of the Life Support Subsystem (LSS) designed for orbital botanical facilities to be flown on Eureca and those of the Environmental Control and Life Support Subsystem (ECLSS) designed for the Columbus carrier are compared. It was found that, while many requirements for the LSS and ECLSS are identical or similar, two requirements (the desired CO2 partial pressure and relative humidity) are not. On the basis of these results, various LSS concepts are discussed which would interact to varying degrees with the ECLSS (in a sense that the ECLSS would be used as a resource for the consumables needed by the LSS). Consideration is given to the advantages and disadvantages of such interaction, in particular the weight savings and technical complexity. I.S.

A87-50792

SPACE STATION - ALL CHANGE?

CHRIS BULLOCH and JOHN RHEA Space Markets (ISSN 0258-4212), Autumn 1986, p. 164-167.

The status of the International Space Station is assessed from a European perspective. NASA's role in coordinating international cooperation is discussed. Particular attention is given to legal concerns. K.K.

A87-51870

STRUCTURE AND DESIGN OF SPACECRAFT [KONSTRUKTSIIA I PROEKTIROVANIE KOSMICHESKIKH LETATEL'NYKH APPARATOV]

NIKOLAI IVANOVICH PANICHKIN, IURII VALENTINOVICH SLEPUSHKIN, VIACHESLAV PAVLOVICH SHINKIN, and NIKOLAI ALEKSANDROVI IATSYNIN Moscow, Izdatel'stvo Mashinostroenie, 1986, 344 p. In Russian. refs

The structure and the general principles of the design of spacecraft and launch vehicles are reviewed. In particular, attention is given to the fundamentals of the theory of jet propulsion and space flight mechanics, selection of the main design parameters of launch vehicles and spacecraft, design of manned spacecraft, and design of spacecraft powerplants. The discussion also covers the selection of structural materials, strength analysis of structural elements, and design of specific spacecraft systems and components. V.L.

A87-53117

AN ADVANCED WIND SCATTEROMETER FOR THE COLUMBUS POLAR PLATFORM PAYLOAD

M. LANGEMANN and R. W. ZAHN (Dornier System GmbH, Friedrichshafen, West Germany) IN: IGARSS '87 - International Geoscience and Remote Sensing Symposium, Ann Arbor, MI, May 18-21, 1987, Digest. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 175-178.

In 1986, ESA/ESTEC performed a study of a payload for the Columbus Polar Platform to be launched in 1995, which shall carry various earth observation instruments. One core instrument is the wind scatterometer, an upgraded version of the ERS-1 wind scatterometer. This paper will describe the instrument design in terms of instrument configuration, electrical design, and on-board data processing. Author

A87-53554#

MICROGRAVITY EXPERIMENTS ONBOARD EURECA [MICROZWAARTEKRACHT-ONDERZOEK AAN BOORD VAN EURECA]

D. FRIMOUT (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) Ruimtevaart, vol. 36, Apr.-June 1987, p. 20-36. In Dutch.

The design of Eureca and the profiles of planned missions are discussed, with an emphasis on reduced-gravity (RG) processing of materials. An overview of RG research is given, including ground RG facilities, the RG environment in LEO, the advantages of RG for material science experiments, and Spacelab-1 RG results. Eureca is a 4000-kg multipurpose platform with 1000-kg payload capacity and a 1-kW solar power system; it is designed for Shuttle or Hermes robot-arm release in LEO (300 km), self-propulsion to 525 km, unattended operation for 6 mo, automatic shutdown to a 'sleeping' state for 1-3 mo, return to 300 km, and retrieval for return to earth. The payload for the first flight (tentatively scheduled for 1991) includes a multifurnace assembly, an automatic mirror facility, a protein-crystallization facility, a solution-growth facility, and an exobiological and radiation facility. Diagrams, drawings, and photographs are provided. T.K.

A87-53558

'HEXE' - X-RAY OBSERVATORY IN SPACE ['HEXE' - ROENTGENOBSERVATORIUM IM WELTRAUM]

Astronautik (ISSN 0004-6221), vol. 24, Apr.-June 1987, p. 41, 42. In German.

An overview is given of the design concept and scientific goals of the High-Energy X-ray Experiment (HEXE), developed in the FRG (by the Max Planck Institute for Extraterrestrial Physics and the Astronomical Institute of Tuebingen University) for operation on the Soviet space station Mir. HEXE was launched to LEO using a Kvant vehicle on March 31, 1987; after initial docking problems, it was joined to Mir by two cosmonauts in a 3-hour EVA on April 12. HEXE has dimensions 45 x 45 x 75 cm and weight 180 kg; it employs an 800-sq-cm Tl-doped NaI/CsI phoswich detector for 15-250-keV X-rays, complementing the other Mir instruments: the ESTEC high-pressure gas-scintillation proportional counter (3-100 keV), the Soviet high-energy detector (20-800 keV), and the Dutch-British X-ray camera (2-30 keV). The Mir observations are intended to explore the energy spectra and time evolution of compact galactic and extragalactic objects. T.K.

A87-53559

THE GDR AND THE SOVIET SPACE PROGRAM - THE OPTICAL INSTRUMENT SECTOR OF THE GDR CONTRIBUTIONS [DIE DDR UND DIE SOWJETISCHE RAUMFAHRT - OPTISCHE GERAETE DOMAENE DER DDR-BEITRAEGE]

KLAUS BURCZIK (Soldat und Technik, no. 2, 1987) Astronautik (ISSN 0004-6221), vol. 24, Apr.-June 1987, p. 43, 44. In German.

The role of the GDR optics and electronics industries in the development of instruments for Soviet spacecraft is discussed. The early importance of German rocket scientists and the participation of GDR cosmonauts are recalled; and individual series of instruments are briefly characterized, including ionic and gas concentration sensors, IR spectrometers for weather satellites, the BES-2 image-data receiver, demodulators for Intersputnik ground stations, the Luch transponders for GEO satellites, and smaller components for several series of experimental and remote-sensing satellites. Special consideration is given to the MKF-6 and MKF-6M multispectral cameras built for use on Salyut; drawings and photographs are provided. T.K.

A87-53560

POWER PLANTS IN SPACE [KOSMISCHE KRAFTWERKE]

SERGEI GRISHIN Astronautik (ISSN 0004-6221), vol. 24, Apr.-June 1987, p. 45, 46. In German.

Proposals for space conversion of solar energy to electric power for earth use are examined. The history of the basic concepts is traced, and the factors to be weighed when considering the construction and operation of such plants are indicated. For example, a system of 150 10-GW GEO power plants (required to meet global requirements for the year 2000) would require space installations of total mass 5-10 million tonnes (and hence orders of magnitude more propellants and semiconductors than the current or predicted world annual production, as well as significant pollution of the atmosphere by rocket launches). The possible use of lunar or asteroidal material to lower launch requirements is discussed, and it is pointed out that large-scale economic, social, political, and ecological problems must be solved before even the most modest proposals (for LEO power satellites) can be undertaken. T.K.

A87-53918#

FROM EURECA-A TO EURECA-B

R. MORY (ESA, Directorate of Space Station and Platforms, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 50, May 1987, p. 24-31.

The design and capabilities of Eureca, a free-flying carrier of space payloads to be launched and retrieved by the Space Shuttle, are described. Eureca is 2.3 m long, weighs 4000 kg at launch, and is supported in the bay by two trunnions and a keel fitting. Consideration is given to the thermal-control system, electrical subsystem, data-handling subsystem, attitude and orbit control subsystem, and orbital transfer assembly of Eureca. The first Eureca-A mission is to consist of microgravity experiments (material and life science) that require long-duration space exposure. The growth capabilities of Eureca-A, and the development of a platform with improved in-orbit capabilities and designed for other space science experiments are discussed. Eureca-B, a three-axis stabilized, retrievable carrier with orbital transfer capabilities, has been developed; the upgraded capabilities that Eureca-B should provide are examined. I.F.

A87-53923#
THE COLUMBUS SYSTEM BASELINE AND INTERFACES
F. LONGHURST (ESA, Space Station and Platforms Directorate, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 50, May 1987, p. 88-97.

The initial and current system requirements, reference configurations, and reference operation concepts for the Columbus system are described. The initial baseline included a pressurized module, a resource module, free-flying unmanned platforms, and an unmanned service vehicle. Changes in the initial design of the Columbus system include: smaller configurations for the coorbiting and polar platforms; the use of a modified Eureca platform; the elimination of the service vehicle; new uses for the pressurized module; the introduction of a man-tended free-flyer (MTFF); the use of Ariane-5 to launch the polar platform and Hermes to service it; and the addition of the European data-relay satellite to the system's communication network. The current design for the Columbus system consists of a pressurized module, an MTFF, and polar and coorbiting platforms. I.F.

N87-20357# Messerschmitt-Boelkow-Blohm/Entwicklungsring Nord, Bremen (West Germany).
RECENT DEVELOPMENTS AND FUTURE TRENDS IN STRUCTURAL DYNAMIC DESIGN VERIFICATION AND QUALIFICATION OF LARGE FLEXIBLE SPACECRAFT
E. HORNUNG, E. BREITBACH (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, West Germany.), and H. OERY (Technische Univ., Aachen, West Germany.) *In* AGARD Mechanical Qualification of Large Flexible Spacecraft Structures 43 p Jul. 1986
Avail: NTIS HC A12/MF A01

A comprehensive dynamic verification concept is proposed, focusing on a multi-axis transient qualification test to be performed on the primary structure or on modular segments of it, respectively. First, practical experiences and development areas identified are addressed. Former existing barriers preventing the practical performance of this verification concepts are no longer relevant because of the extended analytical capabilities due to the positive developments in computer techniques and software and because of the availability of large multi-axis vibration simulators. A vital prerequisite for the applicability of this verification concept is the ability for analytical flightload identification and identification of the true dynamic characteristics on a high quality and reliability level. For this a comparative discussion is presented about the suitability of analytical methods for flightload predictions (shock spectra versus transient methods). The state of the art of design identification tests and of updating methods on mathematical models is summarized and discussed with respect to necessary development areas and the implementation into the proposed structure verification concept. First experience with this new verification cycle was made on a real satellite structure. The results and open development areas identified are discussed. Author

N87-20623# European Space Agency, Paris (France). Directorate of Space Station and Platforms.
THE COLUMBUS PROGRAM: AN OVERVIEW
D. J. SHAPLAND *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 11-17 Nov. 1986
Avail: NTIS HC A07/MF A01

The origins and content of the Columbus program are reviewed. The candidate elements to be studied in phase B2 are described: a pressurized module/laboratory permanently attached to the Space Station core; a man-tended free flyer (pressurized module plus resource module); a polar platform; and a co-orbiting platform based on Eureca technology and experience. A scenario and schedule of events is suggested and discussed in the framework of a total European plan. The importance of user requirements is stressed. ESA

N87-20624# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
EUROPEAN UTILIZATION ASPECTS STUDIES
F. SCHLUDE *In* ESA Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 21-27 Nov. 1986
Avail: NTIS HC A07/MF A01

Starting from a synthesis of space station user data needs, a minimum instrumentation scenario was derived. Grouping of these instruments gave application oriented missions which led to two model missions that can be realized on an international two polar platform system. ESA

N87-20626# Centre National d'Etudes Spatiales, Toulouse (France). SPOT IMAGE.
REMOTE SENSING APPLICATIONS: COMMERCIAL ISSUES AND OPPORTUNITIES FOR SPACE STATION
G. BRACHET *In* ESA Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 35-37 Nov. 1986
Avail: NTIS HC A07/MF A01

The SPOT program is reviewed and the long term prospects beyond SPOT-4 are assessed. Management, legal, and commercial aspects are emphasized. ESA

N87-20627# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ESA COLUMBUS POLAR PLATFORM DESIGN CONCEPT
P. WOLF *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 39-42 Nov. 1986
Avail: NTIS HC A07/MF A01

The Columbus polar platform (PPF) system requirements, configuration, payload complement model, subsystem concepts, and operational aspects are discussed. The PPF is intended to be a large general purpose spacecraft supporting scientific and operational users in a high inclination Earth orbit. Earth observations represent a large percentage of the potential user community, whose requirements essentially determine the design and performance of the PPF. The PPF design is planned to be relatively classical and conservative except for technology for an on-orbit servicing, maintenance, and upgrading capability to extend the life of this large vehicle, and in particular repair, upgrade, and modernize in-orbit the user instruments on board of the PPF, and to bring new instruments up to the PPF at determined intervals after the launch of the spacecraft and its initial payload complement. ESA

N87-20629# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ORBIT CONFIGURATIONS
N. DEVILLIERS *In its* Proceedings of the European Symposium Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 49-53 Nov. 1986
Avail: NTIS HC A07/MF A01

The International Space Station polar platform orbit is discussed. The effect of orbit class, number of orbits, nodal equatorial crossing times, altitude, repeat cycles (linked to altitude), relative phasing of platforms (linked to repeat cycles), and additional platforms are considered. A pair of platforms in Sun synchronous orbit, one in a morning orbit, the other an afternoon is proposed. ESA

N87-20635# Meteorological Office, Bracknell (England).
OCEAN-ICE PANEL REPORT
T. D. ALLAN and A. MOREL *In* ESA Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 85-88 Nov. 1986
Avail: NTIS HC A07/MF A01

Ocean/ice objectives, payload, observation strategy, and data management of Columbus are outlined. Ocean/ice objectives for Columbus should provide continuity to routine remote sensing of the global oceans and ice caps, and over European coastal zones; prepare for an operational system following the experimental and/or pre-operational satellite systems planned to be launched over the next 5yr; develop and test techniques and concepts; provide improved scientific, social and economic benefits; and foster international, interagency cooperative programs aimed at the routine monitoring of the environment. ESA

N87-20636# Belgian Royal Observatory, Brussels.
SOLID EARTH PANEL REPORT
P. PAQUET *In* ESA Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 89-91 Nov. 1986
Avail: NTIS HC A07/MF A01

Investigations of geokinematics, Earth gravity, and geomagnetism by Columbus polar platforms are discussed. Candidate techniques for solid Earth missions, and support from solid Earth studies for Earth observations are considered. ESA

N87-20638# European Space Agency, Paris (France).
PANEL REPORT ON NEW APPROACHES TO CALIBRATION AND VALIDATION
S. BRUZZI *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 99-100 Nov. 1986
Avail: NTIS HC A07/MF A01

The impact of the Columbus polar platform system on calibration and validation; the impact of availability of the space station system (including a coorbiting platform), and the impact of servicing were discussed. ESA

N87-20640# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
THE ORBIT CONFIGURATION PANEL REPORT
D. DEVILLIERS *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumenation for Remote-sensing (ESPOIR) p 103-106 Nov. 1986
Avail: NTIS HC A07/MF A01

The effects on Columbus polar platforms of class of orbits, number of orbits/platforms, nodal crossing times, orbit altitudes, repeat cycles, impact of an additional platform, and impact of having two half-sized platforms in each orbit are reviewed. The impact on meteorological sounders of reducing the altitude; possible choices of repeat cycles and the extent to which compromises can be found because of the conflicts with altitude; and a four-platform scenario, concentrating on the improvements possible in repeat cycles and the altitude choices available should be investigated. ESA

N87-20732# Joint Publications Research Service, Arlington, Va.
SPACE BIOLOGY AND MEDICINE ON THE TWENTY-FIFTH ANNIVERSARY OF THE FIRST SPACEFLIGHT OF YURIY ALEKSEYEVICH GAGARIN
O. G. GAZENKO, N. N. GUROVSKIY, and A. A. GYURDZHIAN *In its* USSR Report: Space Biology and Aerospace Medicine, Vol. 20, No. 3, May - Jun. 1986 (JPRS-USB-86-005) p 1-11 15 Aug. 1986 Transl. into ENGLISH from Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina (Moscow, USSR), v. 20, no. 3, May Jun. 1986 p 4-12
Avail: NTIS HC A08/MF A01

Soviet Space exploration has come a long way in the quarter century that has elapsed after the historical day of the flight of Yu. A. Gagarin on 12 April 1961. The first flight, which lasted only 108 min, was to determine human capacities under conditions prevailing in space. As of 1 January 1986, Soviet cosmonauts had made 109 manned flights involving 60 people. Some of the participants had been in space 2 to 3 and even 5 times (V. A. Dzhanibekov). The Salyut orbital stations became a permanent space research laboratory. The crew consisting of L. D. Kizim, V. A. Solovyev and O. Yu. Atkov worked in space for 237 days. V. A. Dzhanibekov and V. P. Savinykh were able to find and dock with the inactive Salyut-7 station in space, repair it and completely restore its work capacity. In the 25 years that have passed since the first flight, space science has become a solid part of life, an inseparable element of the scientific, economic and sociocultural life of mankind. The file of organizations that are planning spaceflights is full of applications for investigations in the interests of the most diverse scientific disciplines and the national economy. Author

N87-20735# Joint Publications Research Service, Arlington, Va.
EVALUATION OF PHYSICAL WORK CAPACITY OF COSMONAUTS ABOARD SALYUT-6 STATION
V. A. TISHLER, A. V. YEREMIN, V. I. STEPANTSOV, and I. I. FUNTOVA *In its* USSR Report: Space Biology and Aerospace Medicine, Vol. 20, No. 3, May - Jun. 1986 (JPRS-USB-86-005) p 39-45 15 Aug. 1986 Transl. into ENGLISH from Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina (Moscow, USSR), v. 20, no. 3, May Jun. 1986 p 31-35
Avail: NTIS HC A08/MF A01

Electrocardiograms of Salyut-6 prime crewmembers recorded during their exercises on a bicycle ergometer and treadmill are presented. ECG were recorded by a portable tape recorder Cardiocassette and transmitted to the Earth via the radiocommunication channel. This procedure helped to better understand cardiovascular adaptation to different workloads, including submaximal, as well as reserve abilities of the body at various flight stages. This can be used advantageously to correct and control the training process as well as to predict the cardiovascular status at the final flight stage. Author

N87-21979# Joint Publications Research Service, Arlington, Va.
PLANS FOR INDUSTRIALIZATION OF SPACE DISCUSSED
V. S. AVDUYEVSKIY *In its* USSR Report: Space (JPRS-USP-87-001) p 165-174 19 Feb. 1987 Transl. into ENGLISH from Zemlya i Vselennaya (Moscow, USSR), no. 2, Mar. - Apr. 1986 p 2-9
Avail: NTIS HC A11/MF A01

The report by M. S. Borbachev, General Secretary of the CPSU Central Committies, on November 27, 1985, to the session of the USSR Supreme Soviet mentioned a comprehensive program for peaceful collaboration in space and the prospects for the industrial exploitation of space in the interests of all humanity. This program is a peaceful alternative to the misanthropic plans for the militarization of space. It includes the conducting of basic research in space, the creation of global systems of communications satellites, the study of the climate and the environmnet, the development of the science of space materials and medicine, and the creation of new space technology, including orbital scientific stations and manned spacecraft. What can such a program give to humanity if it is realized in the course of the next 25 years of the space era? The answer to this question is considered. Author

N87-21996*# California State Univ., Northridge.
SOVIET SPACE STATIONS AS ANALOGS, SECOND EDITION
B. J. BLUTH and MARTHA HELPPIE Aug. 1986 578 p
(Contract NAGW-659)
(NASA-CR-180920; NAS 1.26:180920) Avail: NTIS HC A25/MF A01 CSCL 22B

The available literature that discusses the various aspects of the Soviet Salyut 6 and Salyut 7 space staions are examined as related to human productivity. The methodology for this analog was a search of unclassified literature. Additional information was obtained in interviews with the cosmonauts and some Soviet space personnel. Topics include: general layout and design of the spacecraft system; cosmonauts role in maintenance and repair; general layout and design of the Mir complex; effects of the environment on personnel; information and computer systems; organization systems; personality systems; and physical conditin of the cosmonaut. B.G.

N87-25031# Consiglio Nazionale delle Ricerche, Rome (Italy). Piano Spaziale Nazionale.
THE COLUMBUS PROGRAM
ALBERTO LORIA *In* ESA Proceedings of the GIREP Conference 1986. Cosmos: An Educational Challenge p 31-36 Nov. 1986
Avail: NTIS HC A20/MF A01

The Columbus permanently manned space station project is outlined. In its first stage Columbus will have tight links with the International Space Station, the assembly of which is planned to start in 1993. Columbus should then develop into an autonomous European space station. The flight elements under negotiation with NASA with necessary ground infrastructures are described. Plans for the utilization of the system are summarized. ESA

N87-25340# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensbereich Apparate.
BOTANICAL PAYLOADS FOR PLATFORMS AND SPACE STATIONS [BOTANISCHE NUTZLASTEN FUER PLATTFORMEN UND RAUMSTATIONEN]
HELMUT R. LOESER 1986 10 p In GERMAN Presented at the 35th Hermann-Oberth-Gesellschaft (HOG) e.V. Raumfahrtkongress, Garmisch-Partenkirchen, West Germany, 2-4 Oct. 1986
(MBB-UR-E-921/86; ETN-87-99954) Avail: Issuing Activity

The development of botanical orbital experiments for space platforms (EURECA) and space stations (Columbus) is presented. The scientific purposes of botanical payloads are outlined. The technological challenges for engineering brought about by such payloads are discussed. Two payloads in the engineering phase, the botany facility for the second EURECA mission, and the gravitational biology facility for the experiments module of Columbus, are presented, as well as their life support systems; the requirements and the solution concepts are discussed. ESA

N87-25418# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensbereich Apparate.
POSSIBILITIES OF THE FURTHER DEVELOPMENT OF COLUMBUS TO AN AUTONOMOUS EUROPEAN SPACE STATION [MOEGLICHKEITEN DER WEITERENTWICKLUNG VON COLUMBUS ZU EINER AUTONOMEN EUROPAEISCHEN RAUMSTATION]
W. WIENSS 1986 22 p In GERMAN Presented at the 35th Hermann-Oberth-Gesellschaft (HOG) e.V. Raumfahrtkongress, Garmisch-Partenkirchen, West Germany, 2-4 Oct. 1986
(MBB-UR-E-922/86; ETN-87-99955) Avail: Issuing Activity

The Columbus program and conceptual ideas for an autonomous, permanently manned space station Columbus are presented. The Columbus program, in its present state of definition, is discussed, with emphasis on the Man-Tended Freeflyer which is the key element for each potential autonomous European space station. The functions of such a space station and the infrastructure in space required for its operation are treated. ESA

N87-26842 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensgruppe Raumfahrt.
CONTROL ENGINEERING TASKS IN THE FRAMEWORK OF THE COLUMBUS PROGRAM [REGELUNGSTECHNISCHE AUFGABEN IM RAHMEN DES COLUMBUS-PROGRAMMS]
WERNER SOBOTTA *In its* Research and Development. Technical-Scientific Publications 1986 p 207-214 1986 In GERMAN Presented at a meeting, Boppard, West Germany, 20-21 Feb. 1986
(MBB-UR-E-912/86) Avail: Issuing Activity

The practical applicability of theoretically developed control systems and methods for control synthesis and optimization was checked and the necessary technology was developed in the framework of the Columbus program for the construction of an American-European space station. Navigation/rendezvous and docking (mission model at a height of 400 km); attitude control; the use of robotics and expert systems; life support systems; and experiment support are discussed. ESA

N87-26953# Centre d'Etudes et de Recherches, Toulouse (France). Dept. Technologie Spatiale.
ON THE POSSIBILITY OF A SEVERAL-KILOVOLT DIFFERENTIAL CHARGE IN THE DAY SECTOR OF A GEOSYNCHRONOUS ORBIT [SUR LA POSSIBILITE DE CHARGE DIFFERENTIELLE DE PLUSIEURS KILOVOLTS DANS LE SECTEUR JOUR DE L'ORBITE GEOSYNCHRONE]
L. LEVY, D. SARRAIL, J. P. PHILIPPON, J. P. CATANI, and J. M. FOURQUET (MATRA Service Aerodynamique, Toulouse, France) *In* AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 12 p May 1987 In FRENCH
Avail: NTIS HC A13/MF A01

Day-sector charging events detected with the Telecom 1-A satellite were analyzed. The temporal distribution of the events, seasonal variations, and correlations with geomagnetic activity are discussed. In addition, several covering materials were subjected to quasi-monoenergetic electron bombardment in a simulation chamber. It was found that floating metallic surfaces, although small, produced enduring discharges with short rise times. M.G.

N87-27887# Joint Publications Research Service, Arlington, Va.
USSR REPORT: SPACE
21 Apr. 1986 140 p Transl. into ENGLISH from various Russian articles
(JPRS-USP-86-004) Avail: NTIS HC A07/MF A01

Topics addressed include: manned mission highlights, space sciences, interplanetary sciences, life sciences, space engineering, space applications, space policy and administration, and launch table.

N87-27888# Joint Publications Research Service, Arlington, Va.
PRAVDA COMMENTARY, PHOTOS OF MIR ORBITAL STATION
A. POKROVSKIY *In its* USSR Report: Space p 3-8 21 Apr. 1986 Transl. into ENGLISH from Pravda (USSR), 21 Feb. 1986 p 1; 3
Avail: NTIS HC A07/MF A01

The Mir and Salyut space stations are compared, relative to mission accomplishments, docking ability, cabin space, crew comfort, efficiency, and crew productivity. B.G.

N87-27893# Joint Publications Research Service, Arlington, Va.
IKI DEPARTMENT HEAD ON ORBITAL POWER PLANTS
YURIY ZAITSEV *In its* USSR Report: Space p 67-69 21 Apr. 1986 Transl. into ENGLISH from APN: Advances of Science and Technology (Moscow, USSR), no. 22, 20 Nov. 1985 p 1-4
Avail: NTIS HC A07/MF A01

The depleting resources of fossil fuels and mankind's growing demand for energy necessitate the search for new sources of energy and revision of the approach to the old ones. The creation of solar power plants in near-earth orbit is discussed as a solution to the problem. B.G.

N87-27895# Joint Publications Research Service, Arlington, Va.
PROGRESS IN THEORY, TECHNOLOGY OF SPACE MATERIALS SCIENCE
YU. OSIPYAN *In its* USSR Report: Space p 97-99 21 Apr. 1986 Transl. into ENGLISH from Pravda (Moscow, USSR), 12 Nov. 1985 p 3
Avail: NTIS HC A07/MF A01

The crews on the Salyut-6 station conducted more than 200 melts and almost as many operations on spraying gold, copper, and various alloys and produced about 300 samples of various materials. Technical experiments now being conducted aboard the Salyut-7 are an important stage in the development of space materials science. Soviet scientists together with specialists from France, are creating equipment which must meet modern requirements from the gas phase and is distinguished by highly accurate temperature maintenance. Another unit is being created through co-operation of Soviet and British scientist. Its intended to study processes of low temperature crystallization out of solutions and promising methods of obtaining crystals of practical value. B.G.

N87-27898# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Space Div.
PRELIMINARY STUDY OF A BIOLOGICAL AND BIOCHEMICAL ANALYSIS FACILITY (BBAF) FOR COLUMBUS: EXECUTIVE SUMMARY Final Report

Paris, France ESA Nov. 1985 44 p Prepared in cooperation with Brunel Univ., Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost, The Netherlands, ORS, Vienna, Austria, and Technical Univ., Graz, Austria
(Contract ESA-6607/85-F-HEW)
(ESA-CR(P)-2338; ETN-87-99967) Avail: NTIS HC A03/MF A01

The feasibility of a compact space laboratory for the performance of complex biological and biochemical assays in a microgravity environment is shown. The laboratory will provide service and support functions to other life science facilities in a common life science mission onboard the pressurized module of Columbus Space Station. Solution to problems due to the use of commercial hardware (for cost reasons) that may cause incompatibility problems (different electronics, etc.) and the limited resources of crew time available are proposed. ESA

N87-27965# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SUMMARY OF RECENT SAR INSTRUMENT STUDIES
D. R. JANSSEN *In its* Proceedings of the SAR Applications Workshop p 111-119 Dec. 1986
Avail: NTIS HC A06/MF A01

Synthetic aperture radar SAR swath widening techniques were studied. Advanced SAR instruments were designed to cover at altitudes up to 900 km incidence angular ranges between 20 and 45 deg providing high image quality with dual frequency or twin SAR's. Broadside looking instruments with dual beam capability are favored. An instrument was sized to fit on the Columbus Polar Platform, which required a reduction of image quality and had to be limited to C-band. Detailed SAR instrument definition is in progress to introduce digital techniques for pulse expansion/compression, and to provide antenna designs with dual beam capability with an optimum technology. ESA

N87-28968# AEG-Telefunken, Wedel (West Germany).
AMOC: AN ALTERNATIVE MODULE CONFIGURATION FOR ADVANCED SOLAR ARRAYS IN LOW EARTH ORBITS
JUERGEN W. KOCH *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 63-70 Nov. 1986 Sponsored by ESTEC
Avail: NTIS HC A21/MF A01

A module concept, based on bifacial Si-solar cells, which also convert Earth albedo radiation to obtain an additional power gain was developed. Tests comprising 15,000 LEO-thermal cycles of real modules, irradiation tests, static load tests, and vibration tests with a fold stack in 2 configurations were conducted. The results show that the chosen design (bifacial cell, transparent substrate, long life interconnector) can meet LEO-mission requirements for extended lifetime. ESA

N87-28974# AEG-Telefunken, Wedel (West Germany).
IMPROVED SOLAR GENERATOR TECHNOLOGY FOR THE EURECA LOW EARTH ORBIT
LOTHAR GERLACH *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 115-121 Nov. 1986
Avail: NTIS HC A21/MF A01

The design and related activities of the electrical part of the EURECA solar array based on the shadow protection requirement and the extreme environment due to the atomic oxygen effects in the EURECA low Earth orbit combined with a high (20,000) number of thermal cycles are discussed. Tradeoff studies for the solar cell selection determined the optimum cell type in respect to power to mass ratio and cost effectiveness. The verification program is summarized and the solar cell technology to be applied for low Earth orbit missions with extended mission life (10 yr) equivalent to 60,000 thermal cycles is identified. ESA

N87-28986# Societe Nationale Industrielle Aerospatiale, Cannes (France).
AEROSPATIALE SOLAR ARRAYS, IN ORBIT PERFORMANCE
J. J. JUILLET, P. SAMSON, L. PELENC, G. HEESCHEN, and K. DETTLAFF (AEG-Telefunken, Wedel, West Germany) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 213-221 Nov. 1986
Avail: NTIS HC A21/MF A01

Correlation between on-ground prediction and in-orbit mechanical and electrical behavior for Telecom-1, ARABSAT, and SPOT solar arrays is shown. When recorded during the deployment phases, the current growth curves allow a good correlation between mechanical models and flight data. Flight data and the performance predictions are well correlated, within the measurement and model accuracies after adjustment of the cell data with ground flasher test results. For geostationary (GEO) missions, transfer orbit degradation may be due to an equivalent radiation dosage lower than usually computed (5 E13 e/sq cm). If so, mismatch and calibration losses may be neglected at BOL, for a nominal power output prediction, this being confirmed by SPOT 1 data analysis. Solar cell degradation due to radiation as observed at the beginning of missions seems to be compatible with an annual equivalent radiation dosage of 5 E13 e/sq cm for GEO missions, and very low for low orbits. ESA

N87-28988# Genoa Univ. (Italy). Dept. di Energetica.
ORGANIC RANKINE CYCLE POWER CONVERSION SYSTEMS FOR SPACE APPLICATIONS
F. FARINA, C. MAO, and G. TUNINETTI (Ansaldo S.p.A., Genoa, Italy) *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 225-230 Nov. 1986
Avail: NTIS HC A21/MF A01

Use of a Rankine heat engine in the Electric Power System (EPS) of a Space Station to convert heat into electricity is discussed. Concentrated solar energy is used to heat a working fluid which in turn drives a turbine operating in a Rankine cycle defined on the basis of the criteria required by a tens of kW EPS. For high reliability, long life, high power/mass ratio, and low collector and radiator area, procedures to optimize the selection of the system and to evaluate the influence of each component on the EPS performance are presented. Tests with toluene and PP3 are proposed. ESA

N87-29015# Physikalisch-Technische Bundesanstalt, Brunswick (West Germany).
ABSOLUTE INDOOR CALIBRATION OF LARGE AREA SOLAR CELLS
J. METZDORF, T. WITTCHEN, and H. KAASE *In* ESA Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 397-401 Nov. 1986 Sponsored by the BMFT
Avail: NTIS HC A21/MF A01

Equipment for the calibration of reference solar cells which is traceable back to their primary radiometric standards is presented. The apparatus, based on the differential spectral responsivity method is an absolute indoor procedure without reference solar cells, and needs no solar simulator. The method is applicable to all kinds of test devices up to solar cell areas of 10 x 10 cm without any requirements on linearity and spectral responsivity of the cells. ESA

N87-29024# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACE 2000 IN EUROPE
K. REINHARTZ and H. STOEWER *In its* Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space p 451-459 Nov. 1986
Avail: NTIS HC A21/MF A01

European space programs including the Columbus space station, Ariane 5, Hermes, Cluster, XMM, Comet Nucleus Sample Return Mission, Infrared Heterodyne Spectroscopy Mission, the microgravity program, the communications program, data relay systems, navigation systems, and space commercialization are summarized. ESA

N87-29553# Joint Publications Research Service, Arlington, Va.
OPTIMIZING EXPERIMENTAL PROGRAMS IN OPERATIONAL PLANNING OF RESEARCH CARRIED OUT FROM SPACECRAFT Abstract Only
M. YU. BELYAYEV and D. N. RULEV *In its* JPRS Report: Science and Technology. USSR: Space p 37 19 Aug. 1987 Transl. into ENGLISH from Kosmicheskiye Issledovaniya (Moscow, USSR), v. 25, no. 1, Jan. - Feb. 1987 p 30-36
Avail: NTIS HC A08/MF A01

An integrated approach is given for optimal preparation of an experimental program for flights of orbital stations of the Salyut type. It is shown that operational planning of experiments is essentially a linear programming program. A set of programs for the BESM-6 computer was developed for use with this method. A specific example is given. Author

19

SUPPORT SPACECRAFT

Includes design, analysis, requirements, trade studies and simulations of Space Station support spacecraft including the orbital transfer vehicle (OTV) and the orbital manuvering vehicle (OMV).

A87-32549
EVALUATION TESTING OF A MECHANICAL ACTUATOR COMPONENT OPERATING IN A SIMULATED SPACE ENVIRONMENT
YASUO KUMAGIRI, HARUKI MARUIZUMI, KOHE OHKAWA (Nissan Motor Co., Ltd., Aeronautical and Space Div., Tokyo, Japan), MAKOTO NISHIMURA, YOSHINORI FUJIMORI (National Aerospace Laboratory, Chofu, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2041-2046.

The conceptual design and lubrication technology development for mechanical actuators for LEO applications are described. The actuators are to function in the deployment/retraction mechanism for a deployable mast for the Japanese experiment module (JEM). Details of the actuator housing are presented, including the interface between the Space Station and typical exposed experiment package to be manipulated. Experimental programs being followed to evaluate dry lubricants and processing technologies are outlined, noting the necessity of identifying areas of complex sliding and rolling friction and wear mechanisms, as well as the effects of space radiation. Electron beam irradiation of MoS2 resulted in no significant chemical or mechanical changes. The form further tests of more integrated systems will take is discussed. M.S.K.

A87-32590* Air Force Space Div., Los Angeles, Calif.
NATIONAL SPACE TRANSPORTATION STUDIES
CORT L. DUROCHER (USAF, Space Div., Los Angeles, CA), THOMAS M. IRBY (NASA, Marshall Space Flight Center, Huntsville, AL), JAMES C. JENKINS (Boeing Aerospace Co., Seattle, WA), and RAYMOND J. GORSKI (General Dynamics Corp., Space Systems, Div., San Diego, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p.
(SAE PAPER 861681)

This paper describes the government and industry activities and findings in response to a Presidential directive to study second-generation space transportation systems. Topics discussed include study purpose, mission needs, architecture development, system concepts, and technology recommendations. Interim study findings will also be presented. The study is being jointly managed by DOD and NASA and equally funded by DOD, NASA, and the Strategic Defense Initiative Organization. Author

A87-38783
THE NEXT STEP FOR THE MMU - CAPABILITIES AND ENHANCEMENTS
LESLIE J. A. ROGERS (Martin Marietta Corp., Denver, CO) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 883-889.
(SAE PAPER 861013)

The Manned Maneuvering Unit (MMU) for untethered astronaut EVAs is a self-contained vehicle incorporating all electrical power, propulsion control, and display components required for such operations as satellite rendezvous, docking and stabilization, as well as the rescuing of crew members, satellite refueling and inspection, and assistance for on-orbit construction of space platforms. Attention is given to prospective improvements of MMU hardware to facilitate its use in Space Shuttle and NASA Space Station-related activities. These enhancements encompass a digital electronics assembly, a navigation aid, and a propellant tank kit. O.C.

A87-43031#
DESIGN PARAMETERS AND ENVIRONMENTAL CONSIDERATIONS FOR A REUSABLE AEROASSISTED ORBITAL TRANSFER VEHICLE
G. R. JONES, M. J. GRUSZCZYNSKI, and K. D. WHITEHEAD (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 6 p. refs
(AIAA PAPER 87-1505)

The factors of thermal protection system TPS design for a foldable, flexible aerobrake are discussed and documented in this study, which presents a practical design approach directed at a Centaur upper stage booster. The basics of the navigational guidance and control concerns are briefly described. Pertinent trades between number of aeropasses, TPS material sizing, and propellant weight to meet system mission requirements are presented. The heating environment and its impact on overall design are described. Several thermal and geometric models were constructed to perform prelimiary analysis and predict the thermal response of the TPS and selected Centaur components. The TPS simulation subjected the concept TPS to the expected heating environment. The increase in number of aeropasses results in reductions in heating rates, maximum temperatures on aerobrake face, and the maximum dynamic pressure but increases the total integrated heat load. These reductions are translated in design into reduced TPS insulation thickness and weight. The increase in the number of aeropasses also results in an increase in the amount of fuel required to complete the mission. Aerobrake backface temperatures and vortex-induced convection will be the predominant heating source for the protected vehicle during re-entry passes. Author

A87-45441#
COMPOSITE FIBER/METAL SPACE STATION TANKAGE - APPLICATIONS, MATERIAL/PROCESS/DESIGN TRADES, AND SUBSCALE MANUFACTURING/TEST RESULTS
TONY M. PEARCE, DALE A. NEVERMAN, FRED J. DARMS, and EDGAR E. MORRIS (Harsco Corp., Structural Composites Industries Div., Pomona, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 9 p.
(AIAA PAPER 87-2157)

Composite fiber/metal tanks are discussed, both their current uses and their specific Space Station applications. Design criteria are outlined. A detailed trade study is presented regarding selection of liner material and processing, fiber, resin, and operating pressure. Relationships between tank weight, fiber selection, and operating pressure are graphically illustrated. Resin and fiber selections as they apply to hypervelocity micrometeoroid impact are discussed. A scaled test demonstration of representative carbon/aluminum Space Station tankage is presented. Author

A87-50533#
LINEAR QUADRATIC CONTROL SYSTEM DESIGN FOR SPACE STATION POINTED PAYLOADS
ROBERT O. HUGHES (General Electric Co., Astro-Space Div., Philadelphia, PA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1247-1254. refs
(AIAA PAPER 87-2530)

A pointing control design using Linear Quadratic techniques and a newly-derived flexible model for the Payload Pointing System (PPS) is developed. Sensitivity of control loop stability to PPS stiffness and damping for a previous PID control design is analyzed. Performance and stability comparisons for three models/controllers are made using both time domain and frequency domain techniques. Author

N87-20633# Science Research Council, Chilton (England).
REPORT OF THE ATMOSPHERE PANEL
J. E. HARRIES and H. FISCHER (Technische Univ., Munich, West Germany.) *In* ESA Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 75-77 Nov. 1986
Avail: NTIS HC A07/MF A01

Policy issues governing the planning of an atmospheric element of a European Polar Platform program were debated. Instrument payloads and observation strategies are suggested. ESA

N87-20637# European Space Agency, Paris (France).
PANEL REPORT ON MULTIDISCIPLINARY INSTRUMENTATION: NEW POSSIBILITIES
G. DUCHOSSOIS *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 95-97 Nov. 1986
Avail: NTIS HC A07/MF A01

The utility of active microwave sensors, passive microwave sensors, high and medium resolution optical sensors, and active optics/laser sensors for the Columbus polar platform Earth observations was assessed. Recommendations concerning SAR, radar altimeters, wind scatterometers, rain radiometers and scatterometers, and microwave radiometers are made. ESA

N87-21018*# General Dynamics Corp., Huntsville, Ala. Advanced Space Programs.
ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY. VOLUME 1A: EXECUTIVE SUMMARY. PHASE 2 Final Report
W. J. KETCHUM Dec. 1986 55 p Sponsored by NASA
(NASA-CR-179055; NAS 1.26:179055; GDSS-SP-86-011-VOL-1A)
Avail: NTIS HC A04/MF A01 CSCL 22B

The objectives of the Phase 2 study were to improve the orbit transfer vehicle (OTV) concept definition by focusing on the following issues: the impact of mission requirements on OTV system design; OTV basing concepts on the Space Shuttle, separate platforms, and/or remote locations; cost reduction of an OTV program to improve its economic benefits and support its acquisition. The OTV mission scenario includes a wide range of missions the main drivers of which are manned GEO servicing, mid-inclination/polar DOD, and lunar/planetary projects. A mission model is presented which includes the type and number of missions per year and the estimated propellant requirements. To accomplish the missions, many OTV concepts were defined including ground-based OTVs launched either in the STS orbiter, the aft cargo carrier, or a heavy lift launch vehicle, and a space-based OTV. System and program trade studies were conducted using performance, cost, safety/risk, and operations/growth criteria. The study shows that mission requirements and substantial economic benefits justify a reusable, cryogenic (H2/O2) space-based OTV. Such a system would not be subjected to Earth-to-orbit launch loads and would not be constained in size or weight. Safety is enhanced by the fact that the system components are launched unfueled. Its inherent reusability and ability to be refueled in space make the space-based OTV very economical to operate. M.G.

N87-23677# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A QUANTITATIVE COMPARISON OF SEVERAL ORBITAL MANEUVERING VEHICLE CONFIGURATIONS FOR SATELLITE REPAIR/REPLENISHMENT M.S. Thesis
JOSEPH H. CAVALLARO 16 Jun. 1987 75 p
(AD-A179106; AFIT/GSO/AA/86D-2) Avail: NTIS HC A04/MF A01 CSCL 22A

The history of spaceflight is full of examples of astronaut crewmembers returning damaged/malfunctioning spacecraft to an operational status. The recent Space Shuttle rescues of Solar Max, Westar and Palapa B-11 are perhaps the most dramatic of these. The current operational concept of servicing the target vehicle on board the shuttle however limits the potential number of spacecraft which can be reached. A potential solution is to use the Orbital Maneuvering Vehicle (OMV) that NASA is developing as a multi-role spacecraft. Use of the OMV has the potential of extending the reach of servicing to spacecraft beyond the range of the Shuttle. This paper examines three OMV/Servicer configurations, including both telepresence and manned version. The Analytic Hierarchy Process is used to rank order the alternatives for further study. A computer program was used to solve for the weights of the various measures of the effectiveness, and resulting priority vector was calculated. Preliminary results show the telepresence servicer rated highest, followed by the full environment manned system. GRA

N87-25582* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PRELOADABLE VECTOR SENSITIVE LATCH Patent
WILLIAM R. ACRES, inventor (to NASA) 28 Jul. 1987 13 p
Filed 3 Oct. 1985 Supersedes N86-19613 (24 - 10, p 1584)
(NASA-CASE-MSC-20910-1; US-PATENT-4,682,745;
US-PATENT-APPL-SN-783888; US-PATENT-CLASS-244-161;
US-PATENT-CLASS-292-DIG.49; US-PATENT-CLASS-292-201;
US-PATENT-CLASS-292-64) Avail: US Patent and Trademark Office CSCL 13K

A preloadable vector-sensitive latch which automatically releases when the force vector from a latch memebr reaches a specified release angle is presented. In addition, it contains means to remove clearance between the latched members and to preload the latch to prevent separation at angles less than the specified release angle. The latch comprises a triangular main link, a free link connected between a first corner of the main link and a yoke member, a housing, and an actuator connected between the yoke member and the housing. A return spring bias means connects the main link to a portion of the housing. A second corner of the main link is slidably and pivotally connected to the housing via a slot in a web portion of the housing. The latch housing has a rigid docking ring alignable with a mating locking ring which is engageable by a locking roller journalled on the third corner of the triangular main link.
Official Gazette of the U.S. Patent and Trademark Office

N87-29861*# University Coll. of North Wales, Bangor.
A MICROGRAVITY ISOLATION MOUNT
D. I. JONES, A. R. OWENS, R. G. OWEN, G. ROBERTS, D. W. WYN-ROBERTS, and A. A. ROBINSON (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* NASA-Lyndon B. Johnson Space Center, The 21st Aerospace Mechanisms Symposium 35-54 May 1987
Avail: NTIS HC A16/MF A01 CSCL 13I

The design and preliminary testing of a system for isolating microgravity sensitive payloads from spacecraft vibrational and impulsive disturbances is discussed. The Microgravity Isolation Mount (MGIM) concept consists of a platform which floats almost freely within a limited volume inside the spacecraft, but which is constrained to follow the spacecraft in the long term by means of very weak springs. The springs are realized magnetically and form part of a six degree of freedom active magnetic suspension system. The latter operates without any physical contact between the spacecraft and the platform itself. Power and data transfer is also performed by contactless means. Specifications are given for the expected level of input disturbances and the tolerable level of platform acceleration. The structural configuration of the mount is discussed and the design of the principal elements, i.e., actuators, sensors, control loops and power/data transfer devices are described. Finally, the construction of a hardware model that is being used to verify the predicted performance of the MGIM is described. Author

N87-29876*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THE PRELOADABLE VECTOR SENSITIVE LATCH FOR ORBITAL DOCKING/BERTHING
WILLIAM R. ACRES and JOHN J. KENNEDY *In its* The 21st Aerospace Mechanisms Symposium p 247-259 May 1987
Avail: NTIS HC A16/MF A01 CSCL 13I

The workings and function of the Preloader Vector Sensitive Latch are described. A discussion of docking systems used in the U.S. manned space flight programs is included to show how docking systems have evolved, and to highlight the potential advantages of a preloadable vector sensitive latch in such systems. Author

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LIFE SCIENCES/HUMAN FACTORS/SAFETY

Includes studies, models, planning, analyses and simulations for biological and medical laboratories, habitability issues for the performance and well-being of the crew, and crew rescue.

A87-33001
HUMAN FACTORS SOCIETY, ANNUAL MEETING, 30TH, DAYTON, OH, SEPT. 29-OCT. 3, 1986, PROCEEDINGS. VOLUMES 1 & 2
Meeting supported by the Human Factors Society, USAF, University of Dayton, et al. Santa Monica, CA, Human Factors Society, 1986. Vol. 1, 758 p.; vol. 2, 754 p. For individual items see A87-33002 to A87-33073.

The conference presents papers on the habitability and facilities of space environments, Forecast II, the validation and application of the criterion task set, visual display research, three-dimensional anthropometry, lifting, visual processes and visual detection, human factors in space, and simulator aftereffects. Other topics include the integration and display of multidimensional information, human factors applications in nonmilitary systems, aviation psychology, design applications in consumer products, and the evaluation of display characteristics. Particular attention is given to the super cockpit and its human factors challenges; individual differences in criterion task set performance; linguistic processing; the use of eye control to select switches; simulated daylight; multimodal interfaces in supervisory control; man/system integration standards for space systems; and USAF experience with simulator sickness, research, and training. K.K.

A87-33002
ISOKIN - A QUANTITATIVE MODEL OF THE KINESTHETIC ASPECTS OF SPATIAL HABITABILITY
DAVID B. LANTRIP (Washington, University, Seattle) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 33-37.

This paper describes a model of the kinesthetic aspect of spatial habitability which is being developed for NASA as a means of assessing the volumetric requirements for the Space Station. The quantitative model, called ISOKIN, defines the level and type of constraint that a confining space imposes on its occupant. An activity will be constrained either in the ways it can be performed (that is, performer adaptation may be required) or in the positions where it can be performed (no adaptation required). This model provides both the analyst and the designer the means to operationalize and measure formerly intuitive notions about the suitability of various proposed Space Station internal configurations for the activities being planned for them. Author

A87-33021
HUMAN PERFORMANCE IN SPACE
DAVID M. REGAL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 365-369.

Space provides a unique living and working environment. Humans in space are, in many respects, different creatures than their earth-bound counterparts (e.g., they float). The paper describes some of the ways in which human capabilities in space are different from those on earth. Psychological and social factors that can affect crew performance on long-duration space missions are discussed. Author

A87-33022
HUMAN FACTORS STANDARDS FOR SPACE HABITATION
BARRY TILLMAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 370-373.

NASA is developing a Man/System Integration Standard. It is to be a single source for human factors engineering standards for the design and development of space habitats. Included in this paper is a discussion of the Anthropometrics, Architecture, Activity Centers, and Health Management sections of the standard. There is a brief description of the general contents of each of these sections and some of the human factors considerations that are unique to the space environment. Author

A87-33475
LIVING IN SPACE: A HANDBOOK FOR SPACE TRAVELLERS
PETER SMOLDERS (Wonen in de ruimte, Bussum, Netherlands, Unieboek, 1985) Blue Ridge Summit, PA, Tab/Aero, 1986, 159 p. Translation.

The state of the art in manned space flight as of 1985 is surveyed and illustrated with extensive drawings and photographs, with an emphasis on the on-orbit living conditions and activities of astronauts on the Space Shuttle and the planned Space Station. Consideration is given to the Shuttle launch facilities; the Shuttle Orbiter; a typical mission profile; the habitat modules for the Space Station; eating, drinking, sleeping, etc. in space; space manufacturing; past Salyut, Skylab, and Spacelab missions; and proposals for colonizing the moon, Mars, and Venus. T.K.

A87-35599
SAFETY ON THE SPACE STATION
MAURA J. MACKOWSKI Space World (ISSN 0038-6332), vol. X-3-279, March 1987, p. 22-24.

Safety features which are either being designed in or considered for the Space Station are discussed briefly. The overall design approach is that of a safe haven, where all modules are independent units to which crew can retreat. The major hazards are fire, meteor impact, or the internal release of hazard materials. Fire extinguishing equipment that was flown on the Gemini, Apollo and Skylab missions is reviewed for the relevancy to the Space Station. A leading design option is a computer-controlled monitoring system that could flood a module with Halon 1301, backed up by portable extinguishers. Several manufacturers are independently pursuing studies of lifeboats for permitting up to seven crewmembers to abandom the Station and parachute to earth in life-threatening emergency. M.S.K.

A87-38701
AEROSPACE ENVIRONMENTAL SYSTEMS; PROCEEDINGS OF THE SIXTEENTH INTERSOCIETY CONFERENCE ON ENVIRONMENTAL SYSTEMS, SAN DIEGO, CA, JULY 14-16, 1986
Conference sponsored by SAE. Warrendale, PA, Society of

Automotive Engineers, Inc. (SAE P-177), 1986, 906 p. For individual items see A87-38702 to A87-38784.
(SAE P-177)

The present conference discusses integrated aircraft fuel thermal management, aircraft fog control systems, food and nutrition in manned spacecraft, a NASA Space Station health maintenance facility, Space Station personal hygiene, radiation dose prediction for the Space Station, the NASA Space Station's Habitation Module, an analysis of crew functions as an aid in Space Station interior layout, the thermal performance of Giotto, systems aspects of Columbus thermal control, and regenerative life support system hardware testing. Also considered are a comparison of environmental control and life support systems requirements for nuclear submarines and the NASA Space Station, space suit reach and strength envelope considerations, an EVA universal work station, a thermal analyzer for two-phase loops, a cryogenic methane heat pipe diode, Space Station air revitalization, long duration botanical experiments in space, plant and animal accommodations aboard the Space Station, spacecraft water recovery, physiological aspects of EVA, the integrated management of water and wastes, and advanced extravehicular crew enclosures. O.C.

A87-38713

ENERGY EXPENDITURE DURING SIMULATED EVA WORKLOADS

REBECCA S. INDERBITZEN (USAF, School of Aerospace Medicine, Brooks AFB, TX) and JAMES J. DECARLIS, JR. IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 109-112. refs
(SAE PAPER 860921)

In ongoing decompression sickness studies at the USAF School of Aerospace Medicine, an exercise regimen is used in which EVA is simulated. A ground-based study was undertaken in order to assess, for the protocol, the currently accepted value of energy expenditure (150-200 kcal/hr) which was based on very limited data. Six male and five female subjects performed an hour of exerise comprised of three tasks analogous to actual tasks performed by astronauts during EVA. Metabolic data were collected using an open-loop oxygen consumption meter during rest and exercise. Gender differences in energy expenditure during performance disappeared when the values were expressed in terms of added energy cost, body weight or lean-body mass. Author

A87-38714* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SPACE MOTION SICKNESS STATUS REPORT

FRANK KUTYNA (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 119-121.
(SAE PAPER 860923)

The space motion sickness (SMS) component of the multifactor space adaptation syndrome is anticipated to be a major problem in the spaceflight and habitation conditions that will be encountered in NASA Space Station tours and Mars voyages. The minimization of maladaptive physiological responses while enhancing those mechanisms that can best cope with the gravitoinertial conditions of space flight will require an intimate knowledge of the physiology of adaptive processes. The homeostatic mechanisms involved in SMS are inherent in human physiology. O.C.

A87-38717

HYPERBARIC OXYGEN THERAPY FOR DECOMPRESSION ACCIDENTS - POTENTIAL APPLICATIONS TO SPACE STATION OPERATION

ANDREW A. PILMANIS (Southern California, University, Catalina, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 151-160.
(SAE PAPER 860927)

The USN's hyperbaric oxygen treatment consists of the administering of 100 percent O2 intermittently to a subject in a hyperbaric chamber, at pressures of 2.73 and 1.82 ATA, and equal parts N2 and O2 at 6.0 ATA. Attention is presently given to the pathophysiology of air embolism and decompression sickness, the basic rationale and goals of hyperbaric oxygen therapy, and the specific treatment tables used by the USN Hyperbaric Chamber Facility, with a view to the application of hyperbaric oxygen therapy for EVA decompression accidents in the future NASA Space Station. O.C.

A87-38718

HABITATION MODULE FOR THE SPACE STATION

GARY JOHNSON, HARRY L. WOLBERS, JR., and WILLIAM L. MILES (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 161-174.
(SAE PAPER 860928)

The habitability requirements of the NASA Space Station, which must support crews for minimum periods of 90 days, are conditioned by the drawing of crewmembers from a wider population than that of the professional astronaut community and the requirement for high crew productivity. Modularity, interchangeability of functional units, commonality of hardware and software, and reconfigurability for changing mission needs and expansion, are additional requirements. The architecture presently proposed consists of longitudinally arranged standoff structural elements attached to the cylindrical pressure wall, through which the common utilities are distributed and to which the modular equipment racks and functional units are attached. O.C.

A87-38721* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SPACE STATION PERSONAL HYGIENE STUDY

STEPHEN E. PREJEAN (Presearch, Inc., Houston, TX) and CLETIS R. BOOHER (NASA, Johnson Space Center, Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 185-200.
(SAE PAPER 860931)

A personal hygiene system is currently under development for Space Station application that will provide capabilities equivalent to those found on earth. This paper addresses the study approach for specifying both primary and contingency personal hygiene systems and provisions for specified growth. Topics covered are system definition and subsystem descriptions. Subsystem interfaces are explored to determine which concurrent NASA study efforts must be monitored during future design phases to stay up-to-date on critical Space Station parameters. A design concept for a three (3) compartment personal hygiene facility is included as a baseline for planned test and verification activities. Author

A87-38724* McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

ANALYSIS OF CREW FUNCTIONS AS AN AID IN SPACE STATION INTERIOR LAYOUT

A. L. STEINBERG, THOMAS S. TULLIS, and BARBRA BIED (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 215-224. refs
(Contract NAS2-11723)
(SAE PAPER 860934)

The Space Station must be designed to facilitate all of the functions that its crew will perform, both on-duty and off-duty, as efficiently and comfortably as possible. This paper examines the

functions to be performed by the Space Station crew in order to make inferences about the design of an interior layout that optimizes crew productivity. Twenty-seven crew functions were defined, as well as five criteria for assessing relationships among all pairs of those functions. Hierarchical clustering and multidimensional scaling techniques were used to visually summarize the relationships. A key result was the identification of two dimensions for describing the configuration of crew functions: 'Private-Public' and 'Group-Individual'. Seven specific recommendations for Space Station interior layout were derived from the anaylses.
Author

A87-38739
THE DEVELOPMENT OF AN EVA UNIVERSAL WORK STATION
MILES MOFFATT and FRED ABELES (Grumman Corp., Bethpage, NY) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 397-403.
(SAE PAPER 860952)

The design requirements for a Space Station-associated EVA Universal Work Station (UWS) which will reduce the overhead costs accruing to multiple trips to and from work sites while increasing crew safety, are discussed. The requirements are established by the variety of work sites and many different EVA tasks, which are characterizable in terms of EVA duration, job performance requirements, work envelope considerations, and translation times. As a result of mission analyses, several design recommendations are made for the EVA UWS system; setup and breakdown time at the work site is noted to be greatly reduced by implementing dedicated work stations at areas of frequent EVA. Tools stored on the UWS, and procedures that are assessed via display system, allow the astronauts to perform the required tasks productively and autonomously.
O.C.

A87-38740* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SCIENCE AND PAYLOAD OPTIONS FOR ANIMAL AND PLANT RESEARCH ACCOMMODATIONS ABOARD THE EARLY SPACE STATION
JOHN D. HILCHEY (NASA, Marshall Space Flight Center, Huntsville, AL), ROGER D. ARNO (NASA, Ames Research Center, Moffett Field, CA), EDITH GUSTAN (Boeing Aerospace Co., Seattle, WA), and C. E. RUDIGER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 405-426. refs
(SAE PAPER 860953)

The resources to be allocated for the development of the Initial Operational Capability (IOC) Space Station Animal and Plant Research Facility and the Growth Station Animal and Plant Vivarium and Laboratory may be limited; also, IOC accommodations for animal and plant research may be limited. An approach is presented for the development of Initial Research Capability Minilabs for animal and plant studies, which in appropriate combination and sequence can meet requirements for an evolving program of research within available accommodations and anticipated budget constraints.
O.C.

A87-38741
SPECIAL CONSIDERATIONS IN OUTFITTING A SPACE STATION MODULE FOR SCIENTIFIC USE
CARL E. RUDIGER, CINDY J. HARRIS, and PAUL C. DOLKAS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 427-433.
(SAE PAPER 860956)

This paper addresses some of the key issues involved with outfitting a space station module for life sciences research, namely the integration of a large diameter centrifuge for holding control specimens at 1 G (or fractions thereof); accommodating international participation in the design and construction of key elements of the lab module (including the module itself); and maintaining biological isolation between the experimental animals and the crew. Several design concepts are presented that address these specific issues. Centrifuge vibration - once thought to be a major problem in a station that also houses materials technology experiments - will be virtually eliminated by the use of an active magnetic suspension and automated rotor balancing. Bioisolation is provided by housing the animals in special isolator cages and performing all experimental work in a laminar flow isolation hood.
Author

A87-38751* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
CONCEPTUAL PLANNING FOR SPACE STATION LIFE SCIENCES HUMAN RESEARCH PROJECT
GARY R. PRIMEAUX (NASA, Johnson Space Center, Houston, TX), LADONNA J. MILLER, and ROGER B. MICHAUD (GE Management and Technical Services Co., Houston, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 531-537. refs
(SAE PAPER 860969)

The Life Sciences Research Facility dedicated laboratory is currently undergoing system definition within the NASA Space Station program. Attention is presently given to the Humam Research Project portion of the Facility, in view of representative experimentation requirement scenarios and with the intention of accommodating the Facility within the Initial Operational Capability configuration of the Space Station. Such basic engineering questions as orbital and ground logistics operations and hardware maintenance/servicing requirements are addressed. Biospherics, calcium homeostasis, endocrinology, exercise physiology, hematology, immunology, muscle physiology, neurosciences, radiation effects, and reproduction and development, are among the fields of inquiry encompassed by the Facility.
O.C.

A87-38766
PHYSIOLOGICAL ASPECTS OF EVA
PAUL A. FURR, CONRAD B. MONSON, WILLIAM J. SEARS, and FRED J. ABELES (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 711-718. refs
(SAE PAPER 860991)

Extravehicular activity (EVA) has become increasingly complex since the days of Gemini. Crewmembers may accumulate as many as 250 hours EVA during a 90 day mission. Physiological parameters and operational variables which were of little or no concern on Shuttle EVAs may become major factors for Space Station EVAs in terms of limiting man's productivity and thus impact EVA scheduling, tasks, and safety. Repeated decompressions, suit oxygen and carbon dioxide levels, metabolic requirements for optimization of work, thermal balance and comfort, and waste collection and management are discussed in this paper. The physiologist must determine the limits of man's adaptation to the space environment within the context of defined, measurable parameters of work performance, or define the change in performance when given an altered environment as the independent variable.
Author

A87-40086
PROPOSED APPLICATION OF AUTOMATED BIOMONITORING FOR RAPID DETECTION OF TOXIC SUBSTANCES IN WATER SUPPLIES FOR PERMANENT SPACE STATIONS
ERIC L. MORGAN (Tennessee Technological University, Cookeville), MICHAEL D. SMITH (Tennessee Valley Authority,

Knoxville), KENNETH W. EAGLESON (North Carolina Department of Natural Resources and Human Development, Raleigh), and RICHARD C. YOUNG (Institute of Environmental Sciences, Space Simulation Conference, 14th, Baltimore, MD, Nov. 1986) Journal of Environmental Sciences (ISSN 0022-0906), vol. 30, Mar.-Apr. 1987, p. 47-49. refs

The objective of this study was to present proposed design characteristics and applications of automated biomonitoring devices for real-time toxicity detection in drinking water supplies on-board permanent space stations. Tests in transmissions of automated biomonitoring data to earth-receiving stations were simulated using satellite data linkage from remote earth-based stations. Emphasis was placed on developing methods for detecting species-specific bioelectric potentials produced by unrestrained bivalve mussels and other sedentary invertebrates since these animals are presumably more easily maintained in near zero gravity than fish. In achieving this objective, differential amplifiers were constructed for measuring a wide range of response signals induced by various biological activities from fish and invertebrate subjects. Specific responses were detected as discrete analog signals, each converted to a digital voltage, and filed in computer storage. A management program provided various means for data gathering, filing, and retrieval. Author

A87-53099
HUMAN CAPABILITIES IN SPACE
BYRON K. LICHTENBERG (Payload Systems, Inc., Wellesley, MA) IN: The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 183-194.
(AAS PAPER 86-114)

The role of humans in space is discussed. The crew is concerned with flying the vehicle, operating experiments, participating in biomedical studies, and exploring outside the spacecraft. The use of the crew to construct large structures, such as the Space Station, in space and the functions of the crew on the Space Station are examined. I.F.

N87-20325*# Colorado Univ., Boulder. Dept. of Aerospace Sciences.
THE GROWTH AND HARVESTING OF ALGAE IN A MICRO-GRAVITY ENVIRONMENT
NANCY L. WILTBERGER *In* NASA. Goddard Space Flight Center The 1986 Get Away Special Experimenter's Symposium p 163-170 Feb. 1987
Avail: NTIS HC A11/MF A01 CSCL 22A

Algae growth in a micro-gravity environment is an important factor in supporting man's permanent presence in space. Algae can be used to produce food, oxygen, and pure water in a manned space station. A space station is one example of a situation where a Controlled Ecological Life Support System (CELSS) is imperative. In setting up a CELSS with an engineering approach at the Aerospace department of the University of Colorado, questions concerning algae growth in micro-g have arisen. The Get Away Special (GAS) Fluids Management project is a means through which many questions about the effects of a micro-g environment on the adequacy of growth rates, the viability of micro-organisms, and separation of gases and solids for harvesting purposes can be answered. In order to be compatible with the GAS tests, the algae must satisfy the following criteria: (1) rapid growth rates, (2) sustain viability over long periods of non-growth storage, and (3) very brief latency from storage to rapid growth. Testing indicates that the overall growth characteristics of Anacystis Nidulans satisfy the specifications of GAS's design constraints. In addition, data acquisition and the method of growth instigation are two specific problems being examined, as they will be encountered in interfacing with the GAS project. Flight testing will be two-fold, measurement of algae growth in micro-g and separation of algae from growth medium in an artificial gravitation field. Post flight results will provide information on algae viability in a micro-g environment as reflected by algal growth rates in space. Other post flight results will provide a basis for evaluating techniques for harvesting algae. The results from the GAS project will greatly assist the continuing effort of developing the CELSS and its applications for space. Author

N87-20342*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIRE SAFETY CONCERNS IN SPACE OPERATIONS
ROBERT FRIEDMAN 1987 13 p Prepared for presentation at the Joint Army-Navy-NASA-Air Force (JANNAF) Safety and Environmental Protection Subcommittee Meeting, Cleveland, Ohio, 4-7 May 1987
(NASA-TM-89848; E-3511; NAS 1.15:89848) Avail: NTIS HC A02/MF A01 CSCL 22A

This paper reviews the state-of-the-art in fire control techniques and identifies important issues for continuing research, technology, and standards. For the future permanent orbiting facility, the space station, fire prevention and control calls for not only more stringent fire safety due to the long-term and complex missions, but also for simplified and flexible safety rules to accommodate the variety of users. Future research must address a better understanding of the microgravity space environment as it influences fire propagation and extinction and the application of the technology of fire detection, extinguishment, and material assessment. Spacecraft fire safety should also consider the adaptation of methods and concepts derived from aircraft and undersea experience. Author

N87-21585*# Southern California Inst. of Architecture, Santa Monica. Inst. for Future Studies.
SPACE STATION GROUP ACTIVITIES HABITABILITY MODULE STUDY Final Report
DAVID NIXON Washington NASA 1986 109 p
(Contract NCC2-356)
(NASA-CR-4010; NAS 1.26:4010) Avail: NTIS HC A06/MF A01 CSCL 06K

This study explores and analyzes architectural design approaches for the interior of the Space Station Habitability Module (originally defined as Habitability Module 1 in Space Station Reference Configuration Decription, JSC-19989, August 1984). In the Research Phase, architectural program and habitability design guidelines are specified. In the Schematic Design Phase, a range of alternative concepts is described and illustrated with drawings, scale-model photographs and design analysis evaluations. Recommendations are presented on the internal architectural, configuration of the Space Station Habitability Module for such functions as the wardroom, galley, exercise facility, library and station control work station. The models show full design configurations for on-orbit performance. Author

N87-22744*# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.
CREW ACTIVITY AND MOTION EFFECTS ON THE SPACE STATION
BRIAN V. ROCHON and STEVEN A. SCHEER *In* NASA. Marshall Space Flight Center Structural Dynamics and Control Interaction of Flexible Structures p 1095-1160 Apr. 1987
(Contract NAS9-15800)
Avail: NTIS HC A99/MF E03 CSCL 22B

Among the significant sources of internal disturbances that must be considered in the design of space station vibration control systems are the loads induced on the structure from various crew activities. Flight experiment T013, flown on the second manned mission of Skylab, measured force and moment time histories for a range of preplanned crew motions and activities. This experiment has proved itself invaluable as a source of on-orbit crew induced loads that has allowed a space station forcing function data base to be built. This will enable forced response such as acceleration and deflections, attributable to crew activity, to be calculated. The flight experiment, resultant database and structural model pre-processor, analysis examples and areas of combined research shall be described. Author

N87-25561*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VAPOR FRAGRANCER Patent Application

Q. TRAN SANG, inventor (to NASA) and TIMOTHY D. BRYANT, inventor (to NASA) 22 May 1987 9 p
(NASA-CASE-LAR-13680-1; US-PATENT-APPL-SN-052941)
Avail: NTIS HC A02/MF A01 CSCL 14B

This invention relates to a vapor fragrancer for continuously, uniformly, and economically odorizing or deodorizing an environment. Homes, offices, automobiles, and space stations require either odorizing or deodorizing of the atmosphere to create pleasant conditions for work or leisure. A vapor fragrancer is provided to accomplish these goals. A supplier continuously supplies a predetermined amount of desired liquid fragrance from a container to a retaining material, which is positioned in the circulation path of the atmosphere. The supplier is either a low powered pump or a gravity dispenser. The atmosphere flowing in a circulation path passes over the retaining material containing the liquid fragrance and lifts a fragrant vapor from the retaining material. The atmosphere is thereby continuously and uniformly fragranced. NASA

21

GENERAL

Includes descriptions, analyses, trade studies, commercial opportunities, published proceedings, seminars, hearings, historical summaries, policy speeches and statements that have not previously been included.

A87-25396*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE EFFECT OF CIRCUMFERENTIAL AERODYNAMIC DETUNING ON COUPLED BENDING-TORSION UNSTALLED SUPERSONIC FLUTTER

D. HOYNIAK (NASA, Lewis Research Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 108, Oct. 1986, p. 253-260. Previously announced in STAR as N86-21513. refs
(ASME PAPER 86-GT-100)

A mathematical model developed to predict the enhanced coupled bending-torsion unstalled supersonic flutter stability due to alternate circumferential spacing aerodynamic detuning of a turbomachine rotor. The translational and torsional unsteady aerodynamic coefficients are developed in terms of influence coefficients, with the coupled bending-torsion stability analysis developed by considering the coupled equations of this aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter as well as the verification of the modeling are then demonstrated by considering an unstable 12 bladed rotor, with Verdon's uniformly spaced Cascade B flow geometry as a baseline. However, with the elastic axis and center of gravity at 60 percent of the chord, this type of aerodynamic detuning has a minimal effect on stability. For both uniform and nonuniform circumferentially space rotors, a single degree of freedom torsion mode analysis was shown to be appropriate for values of the bending-torsion natural frequency ratio lower than 0.6 and higher 1.2. When the elastic axis and center of gravity are not coincident, the effect of detuning on cascade stability was found to be very sensitive to the location of the center of gravity with respect to the elastic axis. In addition, it was determined that when the center of gravity was forward of an elastic axis located at midchord, a single degree of freedom torsion model did not accurately predict cascade stability. Author

A87-32017* National Aeronautics and Space Administration, Washington, D.C.

SPACE RESEARCH - AT A CROSSROADS

FRANK B. MCDONALD (NASA, Washington, DC) Science (ISSN 0036-8075), vol. 235, Feb. 13, 1987, p. 751-754. refs

Efforts which must be expended if U.S. space research is to regain vitality in the next few years are discussed. Small-scale programs are the cornerstone for big science projects, giving both researchers and students a chance to practice the development of space missions and hardware and identify promising goals for larger projects. Small projects can be carried aloft by balloons, sounding rockets, the Shuttle and ELVs. It is recommended that NASA continue the development of remote sensing systems, and join with other government agencies to fund space-based materials science, space biology and medical research. Increased international cooperation in space projects is necessary for affording moderate to large scale missions, for political reasons, and to maximize available space resources. Finally, the establishment and funding of long-range goals in space, particularly the development of the infrastructure and technologies for the exploration and colonization of the planets, must be viewed as the normal outgrowth of the capabilities being developed for LEO operations. M.S.K.

A87-32276

INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 15TH, TOKYO, JAPAN, MAY 19-23, 1986, PROCEEDINGS. VOLUMES 1 & 2

HIROKI MATSUO, ED. (Tokyo, University, Japan) Symposium sponsored by Ad-Melco Co., Ltd., Fujitsu, Ltd., Hitachi, Ltd., et al. Tokyo, AGNE Publishing, Inc., 1986. Vol. 1, 1159 p.; vol. 2, 1111 p. For individual items see A87-32277 to A87-32571.

Papers are presented on national space programs, the future utilization of space, propulsion, materials and structure, flight dynamics and astrodynamics, fluid dynamics, and thermophysics and thermochemistry. Topics discussed include electronic components and devices, space communications, guidance, navigation, and control, systems engineering, space transportation systems. Consideration is given to balloons, space science, the Space Station and space platforms, life sciences, and microgravity. I.F.

A87-32286

SPACE COLONIZATION - T MINUS 20 (YEARS) AND HOLDING

HAROLD J. JEBENS (Marquip, Inc., Phillips, WI) and RICHARD D. JOHNSON (SRI International, Menlo Park, CA) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 67-71. refs

The paper summarizes the findings of a System Design Study undertaken in 1975. The study concluded that a permanent human community for 10,000 people could be placed in space within a 20-year time frame. The paper outlines the objectives of the study, reviews the rational for selecting the location at L5, presents the physiological constraints that dictated the geometry of the habitat, and reviews the economic considerations of the system. Author

A87-32480

COMMERCIALIZATION OF SPACE - THE INSURANCE IMPLICATIONS

BRIAN STOCKWELL and PATRICK OFLAHERTY (Corroon and Black Inspace, Inc., Washington, DC) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1365-1372.

The extent of private sector participation in the commercialization of space will be substantially influenced by the availability and cost of insurance. At present, full insurance costs over the lifetime of a communications satellite may amount to an additional 50 percent or more of the cost of construction and launch. The impact of satellite losses in 1984-1985 led to a reduction of insurance capacity from $250 million to less than $100 million. An evaluation is presently made of the space insurance cost and availability prospects for the 1990s; governmental participation in insurance; the cost tradeoffs between increased design, testing, and redundancy by comparison to attendant reductions in insurance needs and costs; and alternatives to traditional space insurance. O.C.

A87-33019* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MANNED SPACE FLIGHT
BARBARA J. WOOLFORD (NASA, Johnson Space Center, Houston, TX) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 354-357. refs

An overview of manned space flight is given. This describes the key goals and achievements of the space programs of the United States and of the Soviet Union. The importance of the 'Man' in manned space flight is emphasized. Human factors are shown to have played an ever increasing role in the design of manned spacecraft. Author

A87-34597
THE STATION IS RAISING LOTS OF QUESTIONS ABOUT SPACE LAW
Commercial Space (ISSN 8756-4831), vol. 2, no. 4, Winter 1987, p. 43, 45.

The U.S./international space station program may give rise to unprecedented legal questions when it becomes operational, questions involving disputes cpver such things as criminal activity on the station, industrial espionage, intellectual property rights in space, export law, and product liability. agreements among the four space partners - the U.S., Canada, Japan, and the European Space Agency - are needed to clarify the legal questions. Experts believe that some existing laws can be transferred to space, but others will be inapplicable. If the U.S. were to assert sole jurisdiction over the station, other countries could choose to withdraw their participation. Having 'national enclaves' aboard the station is unacceptable to the U.S. Setting up an international governmental organization, such as Intelsat, might be a possibility. A measure to extend U.S. patent laws to cover devices invented aboard launch vehicles and spacecraft is expected to be brought up again during the current legislative session. Although some members of Congress are concerned about adequate protection of U.S. interests, some experts think it would be best to wait and write the laws when the need for them is specifically evident. Author

A87-34870
INNOVATIONS IN SPACE MANAGEMENT - MACROMANAGEMENT AND THE NASA HERITAGE
PHILIP R. HARRIS (Harris International, La Jolla, CA) British Interplanetary Society, Journal (Space Chronicle) (ISSN 0007-084X), vol. 40, March 1987, p. 109-116. refs

Under the leadership of NASA and the National Commission on Space, plans are underway for the next 25 to 50 years in space developments. At the minimum, it involves space and lunar stations that will be complicated to construct and manage, require a new generation of technology, and cost billions of dollars. From these bases in space, planners envision the mining of the moon, then the asteroids, and eventually manned missions to Mars. For such to happen will require an organizational transformation of the National Aeronautics and Space Administration. This may involve changes that give the agency more autonomy and flexibility, especially for long-term financing. Certainly, it should include planned organization renewal so that NASA builds upon the technological and management innovations of its Apollo heritage. To become metaindustrial organizations, NASA and its aerospace partners will have to create a new work culture. For that purpose, the first step should be a survey and assessment of their contemporary organizational culture, so as to ascertain what changes are necessary for future space management. For NASA, the management changes involve new relationships with the military and private sector, as well as with international space consortia and possibly some new entities, such as a global space agency. Author

A87-38576
INTERNATIONAL SAMPE TECHNICAL CONFERENCE, 18TH, SEATTLE, WA, OCT. 7-9, 1986, PROCEEDINGS
J. T. HOGGATT, ED., S. G. HILL, ED., and J. C. JOHNSON, ED. (Boeing Co., Seattle, WA) Conference sponsored by SAMPE. Covina, CA, Society for the Advancement of Material and Process Engineering (International SAMPE Technical Conference Series. Volume 18), 1986, 1137 p. For individual items see A87-38577 to A87-38584, A87-38586 to A87-38643.

The present conference on advanced materials applicable to spacecraft structures and components discusses low distortion tooling for high precision space components, thermoplastic matrix composites, an industrial space facility, composite fabrication process automation, the fusion bonding of thermoplastic composites, failure-resistant bismaleimide/carbon composites, a solvent-resistant thermoplastic, the degradation of teflon in an oxidizing plasma, microgravity processing of zeolites in space, and joint technology for the Space Station truss structure. Also considered are space environment-induced microdamage, composite tubes for the Space Station truss structure, novel polyarylene ethers, composite space antenna structures, the thermal expansion behavior of graphite/glass adn graphite/magnesium, an atomic oxygen beam facility, encapsulants for electronic components, high temperature aromatic matrix systems, and materials issues associated with the Space Station. O.C.

A87-38579
THE INDUSTRIAL SPACE FACILITY
MAXIME A. FAGET (Space Industries, Inc., Webster, TX) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 68-82.

The Industrial Space Facility (ISF) is a manned space platform designed to furnish access to microgravity environments characterized by minimum disturbances. Abundant electrical power, cooling capacity, and pressurized volume with which to support a variety of commercial and government uses will characterize the ISF, in which the operating astronauts will be able to work in 'shirt-sleeve' environmental conditions during servicing and resupply operations. The ISF facility will operate as an autonomous unmanned free-flier between Space Shuttle visits. Flight control and disturbance forces will be minimized through the use of an innovative gravity gradient stabilization and control system. O.C.

A87-38723
A MAINTENANCE WORK STATION FOR SPACE STATION
M. JUNGE (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 207-213.
(SAE PAPER 860933)

The 20-year life cycle of the NASA Space Station calls for the maintenance and repair of critical items in orbit. Attention is presently given to the Maintenance Work Station (MWS), which will be a centralized location for maintenance and repair activities that will contain all tools, equipment, and support functions. The MWS must be integrated into an overall Space Station data management subsystem incorporating direct communication with the inventory control management subsystem, and must exhibit human levels of decisionmaking expertise in order to enhance human operator productivity and reduce task times. O.C.

A87-40068*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THE MECHANICS OF MANUFACTURING IN SPACE
D. C. WADE (NASA, Johnson Space Center, Houston, TX) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 305-308.

The history of the U.S. manned space-flight program is briefly reviewed, with an emphasis on the development of materials-processing technology, and space-manufacturing aspects of the Space Station and proposed lunar and Martian bases are discussed. Consideration is given to the Mercury, Gemini, Apollo, and Apollo-Soyuz missions; Space Shuttle materials-processing experiments; plans for processing electronics crystals, metals, glasses and ceramics, biological materials, and fluids and chemicals on the Space Station; extraction of O2, Fe, Ni, and H2 from lunar materials for use as propellants and in space construction (e.g., of solar power satellites); and the requirements for a permanent base on Mars. T.K.

A87-40296

THE INDUSTRIAL USE OF SPACELAB [DIE INDUSTRIELLE SPACELAB-NUTZUNG]

HANS E. W. HOFFMANN (Hermann-Oberth-Gesellschaft; Intospace GmbH, Hannover, West Germany) (Hermann-Oberth-Gesellschaft, Raumfahrtkongress, 35th, Garmisch-Partenkirchen, West Germany, Oct. 2-4, 1986) Astronautik (ISSN 0004-6221), vol. 24, Jan.-Mar. 1987, p. 8, 9. In German.

Experiments aboard Spacelab that have industrial implications are discussed. The transition from Spacelab to a space station and the D1 Spacelab mission are addressed, stressing the role of the Space Shuttle in experiments with industrial applications. The role of the European user firm Intospace in these efforts is examined. C.D.

A87-41218

RECONSTITUTING THE US SPACE PROGRAMME

JOHN M. LOGSDON (George Washington University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 3, May 1987, p. 86-88.

Proposals to reconstitute the U.S. civilian space program are briefly discussed, with an emphasis on political and economic factors. The symbolic nature of the space program (as a way of demonstrating national power and technological competence) is found to be as important today as it was at the establishment of NASA in 1958 and at the inception of the Apollo program in 1961. It is argued that current NASA funding (about $9 billion per year) is sufficient for a space program comprising projects carefully selected to fulfill these symbolic aims. The elements of such a program include renewal of the technology base to assure access to space for all purposes, appropriate use of the Space Shuttle, a significant role for humans in space, a perceived future for space science and exploration, and a Space Station with broad international participation. T.K.

A87-41222

PRIORITIES AND POLICY ANALYSIS - A RESPONSE TO ALEX ROLAND

JOHN M. LOGSDON Space Policy (ISSN 0265-9644), vol. 3, May 1987, p. 112-114.

This response to Alex Roland's article, 'Priorities in space for the USA' (1987), argues that his analysis and conclusions are based on shaky historical evidence. Professor Roland's interpretation of NASA's priorities since 1959 is challenged, and it is pointed out that the manned spaceflight program has widespread support in the U.S. The most important issue, raised by the article but not treated extensively enough, is whether the pursuit of the widely accepted emphasis on manned spaceflight is a large-scale societal mistake. Author

A87-41569

SPACE: NEW OPPORTUNITIES FOR ALL PEOPLE; SELECTED PROCEEDINGS OF THE THIRTY-SEVENTH INTERNATIONAL ASTRONAUTICAL CONGRESS, INNSBRUCK, AUSTRIA, OCT. 4-11, 1986

L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) Congress sponsored by IAF. Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, 402 p. For individual items see A87-41570 to A87-41575.

The present conference on astronautics considers the NASA Automation and Robotics Technology Program, the objectives and design of the Columbus system, a NASA Space Station development status assessment, international commonality for the Space Station, the Voyager Uranus mission, trends in space transportation, advanced space propulsion concepts, a model test vehicle for hypersonic aerospace system development, and satellite autonomous navigation employing Navsat. Also discussed are the DORIS orbitography and positioning system, a quality assessment of SPOT 1 images, an evaluation of mobile satellite systems, mobile communications, navigation and surveillance, a closed Brayton solar dynamic power system for the Space Station, hydrocarbon rocket propulsion technology, and the Hermes shuttle thermal protection system. O.C.

A87-41571* National Aeronautics and Space Administration, Washington, D.C.

THE SPACE STATION OVERVIEW

JOHN D. HODGE and WILLIAM P. RANEY (NASA, Office of Space Station, Washington, DC) (IAF, International Astronautical Congress on Space: New Opportunities for all People, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, p. 55-62.

This paper is an overview of the Space Station status and activities being undertaken by NASA in cooperation with Canada, the European Space Agency and Japan. A review of the progress within the past year including user requirements, design baseline, operations concept and program planning is covered. Discussion of design decisions and recent changes in the management organization are highlighted. Of special importance is discussion of the Space Station utilization with focus on insuring that the design requirements are responsive to user needs and consistent with life cycle cost. A preliminary operations concept is explored, and options for evolving the Space Station identified. Author

A87-41572

TRENDS IN SPACE TRANSPORTATION

R. F. BRODSKY (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) and M. G. WOLFE (Aerospace Corp., Los Angeles, CA) (IAF, International Astronautical Congress on Space: New Opportunities for all People, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 16, 1987, p. 105-112.

An evaluation is made of emerging design trends in third-generation launch vehicle concepts being entertained in the U.S., Western Europe, and Soviet Union. Novel concepts encompass the horizontal-takeoff-and-landing SSTO, Space Shuttle-derived vehicles, and mammoth heavy lift vehicles. The projected performance capabilities and economic feasibility of these systems are compared. While civilian uses for these vehicles will encompass the extension of current communications and earth observation capabilities and the support of further planetary expeditions, military applications will be dominated by the requirements of the reconnaissance and communication tasks that will be included in the Strategic Defense Initiative system as well as by the constitution of a permanent weapons capability in space. O.C.

A87-42267#

A MODEL FOR THE ESTIMATION OF THE OPERATIONS AND UTILISATION COSTS OF AN INTERNATIONAL SPACE STATION

A. P. FOURNIER-SICRE and R. P. ROGERS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 10, no. 4, 1986, p. 373-380.

To estimate the operations and utilization costs of a subset of the elements of an international space station, certain cost-sharing rules must be developed regarding the common support facilities. To simulate the effect of these strategies, and those of other prime parameters (including transportation, communications, and levels of use of the space station facilities and crew) on the total running costs, a cost model has been developed, together with associated software. Both the methodology employed in the model, and the capabilities of the software are presented. Author

A87-44375

SPACE THE NEXT TWENTY-FIVE YEARS

THOMAS R. MCDONOUGH (California Institute of Technology, Pasadena) New York, John Wiley and Sons, Inc., 1987, 250 p. refs

Prospects for the next 25 years of the U.S. space program are considered. Technical advances that may lead to lunar bases, the development of the Strategic Defense Initiative, interstellar travel, the use of robots in space, space stations, and new SETI methods are examined. Possible scientific missions to study the inner planets, Mars, the asteroids and comets, the outer planets, and the universe are discussed. C.D.

A87-45476

GLOBECOM '86 - GLOBAL TELECOMMUNICATIONS CONFERENCE, HOUSTON, TX, DEC. 1-4, 1986, CONFERENCE RECORD. VOLUMES 1, 2, & 3

Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, Inc., 1986. Vol. 1, 664 p.; vol. 2, 619 p.; vol. 3, 660—p. For individual items see A87-45477 to A87-45559.

Papers are presented on local area networks; formal methods for communication protocols; computer simulation of communication systems; spread spectrum and coded communications; tropical radio propagation; VLSI for communications; strategies for increasing software productivity; multiple access communications; advanced communication satellite technologies; and spread spectrum systems. Topics discussed include Space Station communication and tracking development and design; transmission networks; modulation; data communications; computer network protocols and performance; and coding and synchronization. Consideration is given to free space optical communications systems; VSAT communication networks; network topology design; advances in adaptive filtering echo cancellation and adaptive equalization; advanced signal processing for satellite communications; the elements, design, and analysis of fiber-optic networks; and advances in digital microwave systems. I.F.

A87-46332* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

MAN'S ROLE IN SPACE EXPLORATION AND EXPLOITATION

JOSEPH P. LOFTUS (NASA, Johnson Space Center, Houston, TX) Spaceflight (ISSN 0038-6340), vol. 29, June 1987, p. 240-247.

The crew workloads on the Space Shuttle are described. The Space Shuttle is designed to minimize the activity of the crew in maintaining and operating the Shuttle in order for the crew to be involved in productive activities. The changing role of the crew due to the use of more automated systems on spacecraft is examined. The Shuttle flight system is dependent on embedded software, and the crew is to manage and support these systems. The primary functions of the Space Station are as a laboratory and for construction and assembly of systems, requiring EVA. Examples of EVA are presented. The correlation between manned and unmanned systems and the future direction of space research are discussed. I.F.

A87-46875

WE SHOULDN'T BUILD THE SPACE STATION NOW

ALEX ROLAND (Duke University, Durham, NC) Technology Review (ISSN 0040-1692), vol. 90, July 1987, p. 22, 23.

The present evaluation of the goals and resources of the U.S. space program notes that the construction of a Space Station enjoys only narrow support beyond NASA and the aerospace industry, in the scientific and engineering communities that would be expected to make the greatest use of it. In addition, it is argued that the first phase of Space Station construction will cost far in excess of the $13 billion estimated in April 1987 and be completed significantly later that the 1996 date projected. The Space Station is further alleged to constitute a drain on NASA funds that will starve more productive programs concerned with space science experimentation, and invite more intensive military participation and funding, thereby further complicating the already problematic legal aspects of space use. O.C.

A87-46876

THE SPACE STATION: A PERSONAL JOURNEY

HANS MICHAEL MARK (Texas, University, Austin) Durham, NC, Duke University Press, 1987, 272 p.

An insider's account is given of space science policy and politics during two American presidencies that climaxed in the go-ahead for the Space Station program. The relevant technological debates are addressed in detail, including the effect of the Challenger tragedy. The development of the Shuttle and the relationship of the space program to arms control and other topics are also considered. C.D.

A87-47726

SPACE STATION BUSINESS

PETER GWYNNE High Technology (ISSN 0277-2981), vol. 7, Aug. 1987, p. 10-16.

The competition among aerospace companies for contracts to build the proposed U.S. Space Station is described. It is noted that November 1987 is the decisive time when NASA is expected to award 8-billion dollars worth of work. A chart is presented which lists the lead contractors who will compete for each segment and the major subcontractors working for them. B.J.

A87-47968

SPACE STATION - THE NEXT LOGICAL STEP

ANGELO GUASTAFERRO and MICHELLE A. FARRANCE (Lockheed Missiles and Space Co., Inc., Astronautics Div., Sunnyvale, CA) Lockheed Horizons (ISSN 0459-6773), Dec. 1986, p. 16-26.

The major objectives of the NASA Space Station are to provide an orbiting facility to be used for government, industrial, and academic scientific research, to serve as a base for servicing free-flying spacecraft in earth orbit, to furnish a platform for astronomical and remote-sensing earth observations, and to establish a site for the assembly of spacecraft in orbit. Attention is presently given to projected Space Station laboratory equipment, a health-maintenance facility, a habitability module, EVA systems, and such subsystems as those involved in the Space Station keel lattice structure, passive and active heat rejection, power generation, and mechanical elements. O.C.

A87-48594*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

STANDARDS FOR THE USER INTERFACE - DEVELOPING A USER CONSENSUS

KAREN L. MOE, DOROTHY C. PERKINS, and MARTHA R. SZCZUR (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 6 p. refs
(AIAA PAPER 87-2209)

The user support environment (USE) which is a set of software tools for a flexible standard interactive user interface to the Space Station systems, platforms, and payloads is described in detail. Included in the USE concept are a user interface language, a run time environment and user interface management system, support tools, and standards for human interaction methods. The goals and challenges of the USE are discussed as well as a methodology based on prototype demonstrations for involving users in the process of validating the USE concepts. By prototyping the key concepts and salient features of the proposed user interface standards, the user's ability to respond is greatly enhanced. K.K.

A87-51869

THE GAGARIN SCIENTIFIC LECTURES ON ASTRONAUTICS AND AVIATION, 1986 [GAGARINSKIE NAUCHNYE CHTENIIA PO KOSMONAVTIKE I AVIATSII, 1986 G.]

A. IU. ISHLINSKII, ED. Moscow, Izdatel'stvo Nauka, 1987, 264 p. In Russian. No individual items are abstracted in this volume.

Complete papers are presented on a review of 25 years of manned space flights, space industrialization, and the Vega project. The bulk of the present work contains abstracts of papers presented at the Lectures in such fields as flight mechanics, flight simulation, spacecraft control, spacecraft design and testing, thermal and gasdynamic problems of space flight, spacecraft structural strength, and space manufacturing. B.J.

A87-53083

PERSPECTIVES ON MATERIALS PROCESSING IN SPACE

KURT P. JOHNSON (McDonnell Douglas Astronautics Co., Saint Louis, MO) IN: The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 19-26; Discussion, p. 27.
(AAS PAPER 86-103)

The current status of materials processing in space (MPS) is examined. The advantages the space environment provides to materials processing, and a number of commercial applications for MPS are discussed. The factors which limit the amount of industry involvement in MPS programs are described, and examples of microgravity experiments, such as the continuous electrophoresis process development for separating pharmaceuticals and biologicals produced by advanced biotechnology and the organic polymers and crystals research program, are presented. Consideration is given to the role of the Space Shuttle and Space Station in MPS and the policies necessary to assure continued MPS R&D. I.F.

A87-53085

PROSPECTS FOR SPACE SCIENCE

CARL SAGAN (Cornell University, Ithaca, NY; Planetary Society, Pasadena, CA) IN: The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 . San Diego, CA, Univelt, Inc., 1987, p. 45-51; Discussion, p. 52-55.
(AAS PAPER 86-106)

The use of the space environment for astronomy and the study of the earth is examined. Particular attention is given to the exploration of the electromagnetic spectrum and the solar system. It is argued that it is necessary to complete the proposed missions to rendezvous with a comet and to send an entry probe into the atmosphere of Titan. The need for the development of a Space Station is discussed, and the benefits of manned versus unmanned missions are considered. The political, social, and economic benefits of a joint U.S./Soviet manned mission to Mars are also discussed. I.F.

A87-53924#

COOPERATION BETWEEN EUROPE AND THE UNITED STATES IN SPACE (THE FULBRIGHT 40TH ANNIVERSARY LECTURE)

R. LUEST (ESA, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 50, May 1987, p. 98-104.

The relationship between Europe and the U.S. in space projects is examined. The relationship can be divided into three periods: (1) tutorship of Europe by the U.S., (2) Europe as a junior partner of the U.S., and (3) partnership and competition between Europe and the U.S. The scientific and technical, economic, and political reasons for joint space projects between Europe and the U.S. are discussed. Cooperation between Europe and the U.S. for the development of the Space Station is considered. I.F.

A87-53989

LEADERSHIP IN SPACE TRANSPORTATION

JOEL S. GREENBERG (Princeton Synergetics, Inc., NJ) Space Policy (ISSN 0265-9646), vol. 3, Aug. 1987, p. 178, 180.

The role of the U.S. government, through its civilian space program, in promoting the competitiveness of U.S. marketers of commercial launch services (CLSs) is discussed. The need to concentrate R&D efforts and funding in specific areas (rather than aiming for overall preeminence in space) is indicated, and the competition faced by the U.S. CLS industry in the global market is briefly characterized. It is argued that U.S. CLS marketers would have a distinct advantage if they could offer customers access, on a contractual basis, to the unique on-orbit experimentation and maintenance/repair capabilities of the Space Shuttle and Space Station. It is recommended that long-term commercial and economic factors be given more weight when international cooperation agreements are negotiated. T.K.

N87-20311*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.

PROGRESS ON THE OHIO STATE UNIVERSITY GET AWAY SPECIAL G-0318: DEAP

NESRIN SARIGUL and A. J. MORTENSEN (Gould, Inc., Cleveland, Ohio.) *In* NASA. Goddard Space Flight Center The 1986 Get Away Special Experimenter's Symposium p 59-62 Feb. 1987
Avail: NTIS HC A11/MF A01 CSCL 22A

The Get Away Special program became a major presence at the Ohio State University with the award of GAS-0318 by the American Institute of Aeronautics and Astronautics. There are some twenty engineering researchers and students currently working on the project. GAS-0318 payload is an experimental manufacturing process known as Directional Electrostatic Accretion Process (DEAP). This high precision portable microgravity manufacturing method will revolutionize the manufacture and repair of spacecraft and space structures. The cost effectiveness of this process will be invaluable to future space development and exploration. Author

N87-20632# European Space Agency, Paris (France).

USA-EUROPE COORDINATION AND COOPERATION ACTIVITIES: ANNOUNCEMENTS OF OPPORTUNITY

G. DUCHOSSOIS *In its* Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-sensing (ESPOIR) p 69-71 Nov. 1986
Avail: NTIS HC A07/MF A01

International Space Station polar platform Announcements of Opportunity objectives, content, schedule, evaluation and selection process, address, funding sources, data access and rights, as discussed and agreed within the Coordination Group are outlined. ESA

N87-20667*# Rockwell International Corp., Canoga Park, Calif. Rocketdyne International.

DENSITY UNCERTAINTY EFFECT ON COST OF SPACE STATION REBOOST Abstract Only

WALTER UNTERBERG and CLAUS MEISL *In* NASA. Marshall Space Flight Center Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations p 39-40 Feb. 1987
Avail: NTIS HC A13/MF A01 CSCL 22B

If the space station is designed for operation in a nominal atmosphere for ten years and the atmosphere is two-sigma higher than nominal during the entire ten year period, the impact would be an additional cost of $70.1 million, based on a resupply cost of $3200/lb. A cost analysis of the space station fuel consumption with reboost is presented. Author

N87-21753# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

PRESENT AND FUTURE MILITARY USES OF OUTER SPACE: INTERNATIONAL LAW, POLITICS, AND THE PRACTICE OF STATES M.S. Thesis

DONALD E. WALSH Aug. 1986 211 p
(AD-A176722; AFIT/CI/NR-87-19T) Avail: NTIS HC A10/MF A01 CSCL 15C

This thesis examines the present and future military uses of outer space with an emphasis on the policies and practices of international states. These policies and practices are examined in the context of the emergence of international space law. The thesis proceeds from an examination of the early years of the space age and move to an examination of the present and future military uses of outer space. Next is given a review of international treaties affecting military activities in outer space. The law is then applied to the present and future activities examined above, with prospects for the future. GRA

N87-21754# Office of Technology Assessment, Washington, D.C.

SPACE STATIONS AND THE LAW: SELECTED LEGAL ISSUES

Sep. 1986 88 p

(PB87-118220; OTA-BP-ISC-41; LC-86-600569) Avail: NTIS HC A05/MF A01 CSCL 05D

Part 1 is a background paper which discusses the legal consequences of developing and operating the space station. This paper examines the different ways in which a multinational space station might be owned and operated and explains how each could affect the rights and responsibilities of the U.S. Government and its citizens. In addition, it gives special attention to the application of jurisdiction, tort law, intellectual property, and criminal law to nations and individuals living and working in space. Part 2 of this report is a summary of the workshop held by OTA to critique and expand on the initial drafts of Part 1. GRA

N87-22580# Committee on Appropriations (U.S. House).

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT-INDEPENDENT AGENCIES APPROPRIATIONS FOR 1988

Washington GPO 1987 1031 p Hearings before the Subcommittee on HUD-Independent Agencies of the Committee on Appropriations, 100th Congress, 1st Session, 7 Apr. 1987

(GPO-73-418) Avail: Subcommittee on HUD-Independent Agencies

The Federal Budget requests by the National Aeronautics and Space Administration for the Fiscal Year 1988 are discussed. These requests cover the expenditure for returning the Shuttle to flight status; commitments to the space station; space science and applications; space research and technology; space tracking and data systems; institutional programs; and construction and maintenance. B.G.

N87-22987# Lawrence Livermore National Lab., Calif.

TOWARD THE YEAR 2000: THE NEAR FUTURE OF THE AMERICAN CIVILIAN AND MILITARY SPACE PROGRAMS

L. L. WOOD and M. Y. ISHIKAWA Jan. 1987 10 p Presented at the 3rd National Space Symposium of the US Space Foundation, Colorado Springs, Colo., 20 Jan. 1987

(Contract W-7405-ENG-48)

(DE87-006457; UCRL-96258; CONF-870162-1) Avail: NTIS HC A02/MF A01

The basic features of the American civilian and military space programs at the end of this century are identified and their histories traced back to the present time, for the surprise-free scenario. Several of the more likely surprises are noted, and their probable impacts sketched. DOE

N87-24240# Committee on Commerce, Science, and Transportation (U.S. Senate).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT

Washington GPO 1987 47 p A bill, S. 1164, referred to the Committee on Commerce, Science and Transportation, 100th Congress, 1st Session, 7 May 1987

(S-REPT-100-87) Avail: US Capitol, Senate Document Room

Appropriations for the National Aeronautics and Space Administration for research and development, space flight, control and data communication, construction of facilities, and research and program management are discussed. B.G.

N87-24486*# National Aeronautics and Space Administration, Washington, D.C.

SPACE STATION: A PROGRAM OVERVIEW

JUDITH H. AMBRUS *In* NASA-Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 579-590 Jun. 1987

Avail: NTIS HC A14/MF A01 CSCL 22B

An overview is presented of the NASA program for the development of the Space Station. A general representation of the initial Space Station complex is shown. The Space Station goals and program objectives are briefly reviewed, as well as the program schedule. An advanced development program and program management approach are also presented. E.R.

N87-25024# Committee on Science, Space and Technology (U.S. House).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, FISCAL YEAR 1988

Washington GPO 1987 270 p Report on H.R. 2782 presented by the Committee on Science, Space and Technology to the Committee of the Whole House on the State of the Union, 100th Congress, 1st Session, 7 Jul. 1987

(H-REPT-100-204; GPO-69-358) Avail: NTIS HC A12/MF A01

Appropriations to the National Aeronautics and Space Administration (NASA) are reviewed for research and development; space flight, control, and data communications; construction of facilities, and research and development management. B.G.

N87-25354# European Space Agency, Paris (France).

PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON SPACECRAFT FLIGHT DYNAMICS

T. D. GUYENNE, comp. and J. J. HUNT, comp. Dec. 1986 501 p Symposium held in Darmstadt, West Germany, 20-23 Oct. 1986

(ESA-SP-255; ISSN-0379-6566; ETN-87-99862) Avail: NTIS HC A22/MF A01

Flexible spacecraft dynamics; halo orbits; interplanetary trajectories; geostationary satellites; precise orbit determination; onboard systems and spacecraft hardware; orbital mechanics; spinning spacecraft; satellite tracking; and ground systems were discussed.

ESA

N87-25760*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

WORKSHOP ON WORKLOAD AND TRAINING, AND EXAMINATION OF THEIR INTERACTIONS: EXECUTIVE SUMMARY

EMANUEL DONCHIN (Illinois Univ., Urbana-Champaign.), SANDRA G. HART, and EARL J. HARTZELL Jul. 1987 40 p Workshop held in Carmel, Calif., 5-10 Jan. 1986

(NASA-TM-89459; A-87212; NAS 1.15:89459) Avail: NTIS HC A03/MF A01 CSCL 05H

The goal of the workshop was to bring together experts in the fields of workload and training and representatives from the Dept. of Defense and industrial organizations who are reponsible for specifying, building, and managing advanced, complex systems. The challenging environments and requirements imposed by military helicopter missions and space station operations were presented as the focus for the panel discussions. The workshop permitted a detailed examination of the theoretical foundations of the fields of training and workload, as well as their practical applications. Furthermore, it created a forum where government, industry, and academic experts were able to examine each other's concepts, values, and goals. The discussions pointed out the necessity for a more efficient and effective flow of information among the groups respresented. The executive summary describes the rationale of the meeting, summarizes the primary points of discussion, and lists the participants and some of their summary comments.

Author

N87-25815# Air Command and Staff Coll., Maxwell AFB, Ala.

MILITARY MAN IN SPACE: A HISTORY OF AIR FORCE EFFORTS TO FIND A MANNED SPACE MISSION Student Report, 1945 - 1987

TIMOTHY D. KILLEBREW Feb. 1987 77 p

(AD-A179873; ACSC-87-1425) Avail: NTIS HC A05/MF A01 CSCL 12B

This report traces the Air Force's efforts to find a manned military space role. It begins with the development of Dyna Soar shortly after World War II. The author traces Dyna Soar's evolution and political problems that caused its eventual cancellation and discusses the Manned Orbiting Laboratory from its beginnings in

1963 until its cancellation in 1969. He also gives the potential uses of the Manned Orbiting Laboratory and the reasons behind its cancellation. The beginnings of the Space Transportation System and the reasons behind the Air Force's decision to use STS as the sole means of entering space are traced. The study concludes with a short discussion on the future of Air Force manned space efforts including a follow-on to the Space Shuttle and the probability of a space station. GRA

N87-29984# Army War Coll., Carlisle Barracks, Pa.
MILITARY SPACE STATION IMPLICATIONS
GARRETT D. BOURNE, GLEN D. SKIRVIN, and GERALD R. WILSON 23 Mar. 1987 186 p
(AD-A180831) Avail: NTIS HC A09/MF A01 CSCL 22B

The relevancy of a Manned Military Space Station (MMSS) and its deployment to capitalize on the United States' national security interests is the purpose of this report. The MMSS is intended to perform a two-fold purpose: (1) facilitate military peacetime operations while simultaneously supporting and promoting civilian space initiatives; and, (2) act as a force multiplier for space and terrestrial force operations in the event of conventional, theater nuclear, and/or strategic nuclear war. Data to support the future value of the MMSS was obtained from individual and group research using unclassified sources such as professional journals, books, US Air Force Staff College reference material, and information from the US Air Force space coordinating staff in Washington, D.C. The importance of space to our future and especially of a MMSS by America's national leaders and its people has yet to be fully appreciated and/or realized. The significance of space and its nexus to the United States' national security has been growing in importance since Sputnik in 1957. Space cannot and should not be understated in importance as it relates to commerce, war deterrence, and to the stability of world order. GRA

N87-29155*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TESTING AND ANALYSIS OF DOD ADA LANGUAGE PRODUCTS FOR NASA
In NASA, Washington, Proceedings: Computer Science and Data Systems Technical Symposium, Volume 2 20 p Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 09B

An activity is described that is keyed to Johnson Space Center's role as an Ada/APSE test site. Specific objectives and concerns relative to potential utilization of Ada for the Space Station are discussed. Finally, detailed discussion is provided concerning study tasks soon to be contracted out for detailed investigation and project risk assessment. Author

N87-30220# Committee on Appropriations (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Department of Housing and Urban Development - Independent Agencies Appropriation Bill, 1988 p 64-73 6 Oct. 1987
Avail: NTIS HC A06/MF A01

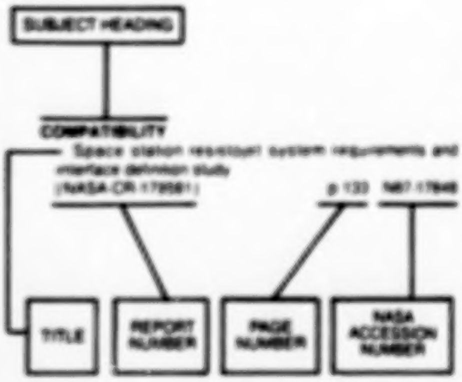
The objectives of the NASA program of research and development are to extend the knowledge of the Earth, its space environment, and the universe; to expand the practical applications of space technology; to develop, operate, and improve unmanned space vehicles; to provide technology for improving the performance of aeronautical vehicles while minimizing the environmental effects and energy consumption; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. The appropriations necessary to accomplish these goals are examined. B.G.

N87-30221# Committee on Commerce, Science, and Transportation (U.S. Senate).
NASA AUTHORIZATION: AUTHORIZATION OF APPROPRIATIONS FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR FISCAL YEAR 1988
Washington GPO 1987 471 p Hearings on S-Hrg-100-231 before the Subcommittee on Science, Technology and Space of the Committee on Commerce, Science and Transportation, 100th Congress, 1st Session, 3, 19, 26 Feb.; 5 Mar. and 29 Apr. 1987
(GPO-73-245) Avail: NTIS HC A20/MF A01

Appropriations for the FY88 budget for NASA are examined. Prioritization of the four upcoming planetary missions-Galileo, Ulysses, Magellan, and the Mars Observer is discussed. Obstacles which delay the return of the shuttles to service and which delay the building of the space station are also discussed. B.G.

SUBJECT INDEX

Typical Subject Index Listing


SUBJECT HEADING
COMPATIBILITY
Space station resistojet system requirements and interface definition study
(NASA-CR-179581) p 133 N87-17848
TITLE
REPORT NUMBER
PAGE NUMBER
NASA ACCESSION NUMBER

The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identify the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

ABSORPTANCE
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-22346

AC GENERATORS
Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-26735
Resistojet control and power for high frequency ac buses
[AIAA PAPER 87-0994] p 58 A87-41153
Resistojet control and power for high frequency ac buses
[NASA-TM-88090] p 62 N87-20477

ACCELERATION (PHYSICS)
Crew activity and motion effects on the space station p 165 N87-22744
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
Optimal shuttle altitude changes using tethers
[AD-A178858] p 129 N87-22758

ACCESS CONTROL
Proof that timing requirements of the FDDI token ring protocol are satisfied --- fiber distributed data interface p 112 A87-42821

ACCIDENTS
Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation
[SAE PAPER 860927] p 160 A87-38717

ACCUMULATORS
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38764

ACCURACY
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 6 A87-33060

ACOUSTIC EMISSION
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179187] p 4 N87-28583

ACOUSTIC FREQUENCIES
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLPF method p 144 A87-22334

ACOUSTIC PROPAGATION
Vibrations and structureborne noise in space station
[NASA-CR-181381] p 39 N87-29580

ACOUSTICS
Acoustic effects on the dynamic of lightweight structures p 26 N87-20372

ACTIVE CONTROL
Two-time-scale design of robust controllers for large structure systems p 12 A87-22443
Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32657
Vibration suppression using a constrained rate-feedback Threshold control strategy --- for large space structures
[AIAA PAPER 87-0741] p 6 A87-33085
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0900] p 17 A87-33712
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 58 A87-33713
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0901] p 19 A87-34701
System aspects of Columbus thermal control
[SAE PAPER 860936] p 150 A87-38727
Actuators for actively controlled space structures p 59 A87-42816
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42817
Space station active thermal control system modeling
[AIAA PAPER 87-1480] p 43 A87-43503
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
Active damping control design for the COFS Mast Flight System --- Control of Flexible Structures program for NASA
[AIAA PAPER 87-2321] p 23 A87-50442
Active vibration control synthesis for the COFS-I - A classical approach --- Control of Flexible Structures experiment for NASA
[AIAA PAPER 87-2322] p 23 A87-50443
An analytical and experimental investigation of output feedback vs. linear quadratic regulator --- for large space structures
[AIAA PAPER 87-2390] p 61 A87-50474
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502
Active structural controllers emulating structural elements by ICUs p 27 N87-20087
Air Force basic research in dynamics and control of large space structures p 63 N87-20577
Microprocessor controlled proof-mass actuator p 65 N87-22708
Optimum mix of passive and active control of space structures p 65 N87-22714
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721
Workshop on Structure Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
Vibration suppression by stiffness control p 66 N87-22730
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181080] p 34 N87-23960
Joint Optics Structures Experiment (JOSE) p 34 N87-24487
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179728] p 35 N87-24517
Distributed control using linear momentum exchange devices
[NASA-TM-100306] p 70 N87-24521
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-89094] p 70 N87-24723
Active vibration damping of flexible structures using the traveling wave approach p 71 N87-25280
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181156] p 36 N87-25605
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-25605
Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180633] p 37 N87-26385
Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-26387
Active vibration control in microgravity environment p 72 N87-26700
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-28713

ACTUATORS
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel p 55 A87-32446
Study of actuator for large space manipulator arm p 12 A87-32542
Evaluation testing of a mechanical actuator component operating in a simulated space environment p 150 A87-32549
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32739
On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0887] p 16 A87-33709
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0959] p 16 A87-33751
Development of harmonic drive actuator for space manipulator p 149 A87-35076
A study on singularity of single gimbal CMG systems p 149 A87-35077
Actuators for actively controlled space structures p 59 A87-42816
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
Suboptimal feedback vibration control of a beam with a proof-mass actuator --- large space structures
[AIAA PAPER 87-2323] p 23 A87-50444
Active structural controllers emulating structural elements by ICUs p 27 N87-20087
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
Microprocessor controlled proof-mass actuator p 65 N87-22708
On the control of structures by applied thermal gradients p 35 N87-22747
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181080] p 34 N87-23960
Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-26387
An investigation of methodology for the control and failure identification of flexible structures p 36 N87-26421
The 21st Aerospace Mechanisms Symposium
[NASA-CP-2470] p 103 N87-26868
Common drive unit p 104 N87-26886
An electromechanical attenuator/actuator for Space Station docking p 139 N87-26879
Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-26888

ADA (PROGRAMMING LANGUAGE)
Testing and analysis of DOD Ada language products for NASA p 172 N87-29152

ADAPTIVE CONTROL

Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33667

Adaptive tracking of dynamical model by uncertain nonlinearizable spacecraft
[AIAA PAPER 87-0940] p 57 A87-33738

An overview of controls research on the NASA Langley Research Center grid p 66 N87-22720

Moving-bank multiple model adaptive estimation applied to flexible spacestructure control
[AD-A178870] p 68 N87-22761

Control technology overview in CSI
p 69 N87-24507

ADAPTIVE FILTERS

Adaptive identification of flexible structures by lattice filters
[AIAA PAPER 87-2458] p 24 A87-50504

ADHESIVE BONDING

Joint technology for graphite epoxy space structures
p 20 A87-38600

Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-38643

AEROACOUSTICS

Documentation of the space station/aircraft acoustic apparatus
[NASA-TM-89111] p 140 N87-20795

AEROASSIST

Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31681

Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744

Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1505] p 160 A87-43031

Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2566] p 136 A87-49618

Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2464] p 93 A87-50509

Aero-Assisted Orbital Transfer Vehicle (AOTV)
p 3 N87-20682

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5). Volume 1A, part 1: Executive summary, phase 1
[NASA-CR-179139] p 87 N87-26062

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2
[NASA-CR-179140] p 3 N87-26063

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 3: Cost estimates and work breakdown structure/dictionary, phase 1 and 2
[NASA-CR-179144] p 3 N87-26064

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 2: Supporting research and technology report, phase 1 and 2
[NASA-CR-179143] p 3 N87-26065

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results
[NASA-CR-179141] p 4 N87-26066

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results
[NASA-CR-179142] p 4 N87-26067

Singular perturbation analysis of AOTV related trajectory optimization problems
[NASA-CR-180301] p 137 N87-26927

Optimal nodal transfer and aeroassisted transfer by aerocruise p 138 N87-28577

AEROBRAKING

Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744

Aero-Assisted Orbital Transfer Vehicle (AOTV)
p 3 N87-20682

AERODYNAMIC CONFIGURATIONS

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results
[NASA-CR-179141] p 4 N87-26066

AEROELASTICITY

Interdisciplinary analysis procedures in the modeling and control of large space-based structures
p 22 A87-42678

Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183302] p 11 N87-29893

AEROMANEUVERING

Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49615

Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2567] p 93 A87-49617

SAFE/DAE: Modal test in space p 77 N87-20584

Singular perturbation analysis of AOTV related trajectory optimization problems
[NASA-CR-180301] p 137 N87-26927

Optimal nodal transfer and aeroassisted transfer by aerocruise p 138 N87-28577

AERONAUTICS

The Gagarin scientific lectures in astronautics and aviation, 1985 — Russian book p 152 A87-42923

The Gagarin Scientific Lectures on Astronautics and Aviation, 1986 — Book p 169 A87-51869

AEROSPACE ENGINEERING

Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 p 13 A87-33551

Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Parts 2A & 2B
p 15 A87-33654

A modern approach for modal testing using multiple input sine excitation
[AIAA PAPER 87-0964] p 19 A87-33754

An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340

USSR Report: Space
[JPRS-USP-86-004] p 158 N87-27687

AEROSPACE ENVIRONMENTS

Development of graphite epoxy space structure
p 105 A87-32342

Assessment of space environment induced microdamage in toughened composite materials
p 20 A87-38609

Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41611

Liquid droplet radiator development status — waste heat rejection devices for future space vehicles
[AIAA PAPER 87-1537] p 43 A87-43059

Hydrogen-oxygen thruster with no products of combustion in exhaust plume
[AIAA PAPER 87-1775] p 91 A87-45196

Taylored laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794

Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 138 N87-20306

The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325

Liquid droplet radiator development status
[NASA-TM-89852] p 44 N87-20353

Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180698] p 28 N87-20569

Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations
[NASA-CP-2460] p 64 N87-20665

Microgravity Fluid Management Symposium
[NASA-CP-2465] p 94 N87-21141

Advanced long term cryogenic storage systems
p 94 N87-21142

Mixing-induced fluid destratification and ullage condensation p 95 N87-21149

Superfluid helium on orbit transfer (SHOOT)
p 95 N87-21151

Microgravity fluid management in two-phase thermal systems p 95 N87-21152

Microgravity fluid management requirements of advanced solar dynamic power systems
p 77 N87-21153

Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154

Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21996

Spacecraft environment interaction investigation
[AD-A179183] p 140 N87-22678

Ideas for educational physics experiments in space
p 130 N87-25033

Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4091] p 53 N87-26096

Pravda commentary, photos of Mir orbital station
p 158 N87-27686

Space stable thermal control coatings
[AD-A182796] p 110 N87-28584

Automated Subsystem Control for Life Support System (ASCLSS)
[NASA-CR-172003] p 53 N87-29117

AEROSPACE INDUSTRY

Computerized aerospace materials data; Proceedings of the Workshop on Computerized Property Materials and Design Data for the Aerospace Industry, El Segundo, CA, June 23-25, 1986 p 111 A87-35252

AEROSPACE MEDICINE

Space Station - Opportunities for the life sciences
p 122 A87-34871

When the doctor is 200 miles away
p 47 A87-35600

Radiation environments and absorbed dose estimations on manned space missions p 139 A87-49026

Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-49030

Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732

An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A178235] p 68 N87-23681

AEROSPACE PLANES

Physiological requirements and pressure control of a spaceplane
[SAE PAPER 860965] p 150 A87-38747

The Soviet space shuttle programme
p 153 A87-47302

AEROSPACE SAFETY

Safety on the Space Station p 162 A87-35596

AEROSPACE SCIENCES

K.E. Tsiolkovskii and problems in the development of science and technology — Russian book
p 151 A87-40342

The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53062

Prospects for space science
[AAS PAPER 86-106] p 170 A87-53085

AEROSPACE SYSTEMS

Control operations in advanced aerospace systems
p 54 A87-32117

Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986
[SAE P-177] p 162 A87-38701

Structure and design of spacecraft — Russian book
p 155 A87-51870

Technology projections and space systems opportunities for the 2000-2030 time period
[AAS PAPER 86-109] p 2 A87-53086

Spacecraft environment interaction investigation
[AD-A179183] p 140 N87-22678

AEROTHERMODYNAMICS

The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results
[NASA-CR-179141] p 4 N87-26066

AGING (MATERIALS)

Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-38643

AIR

Acoustic effects on the dynamic of lightweight structures p 28 N87-20372

AIR CONDITIONING

An evolutionary approach to the development of a CELSS based air revitalization system
[SAE PAPER 860968] p 49 A87-38750

AIR FLOW

Vapor fragrancer
[NASA-CASE-LAR-13680-1] p 165 N87-25061

AIR LAW

Present and future military uses of outer space: International law, politics, and the practice of states
[AD-A176722] p 170 N87-21753

AIR LOCKS

A multiple attribute decision analysis of manned airlock systems
[AD-A178241] p 137 N87-23682

AIR NAVIGATION

AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volumes 1 & 2 p 60 A87-50401

AIR PURIFICATION

Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733

Space Station life support oxygen generation by SPE water electrolyzer systems
[SAE PAPER 860949] p 49 A87-38736

Hydrogen/oxygen economy for the space station
p 98 N87-28130

AIR QUALITY

Vapor fragrancer
[NASA-CASE-LAR-13680-1] p 165 N87-25061

AIR TO AIR REFUELING
An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-25888
AIR WATER INTERACTIONS
An advanced wind scatterometer for the Columbus Polar Platform payload p 155 A87-53117
AIRBORNE/SPACEBORNE COMPUTERS
Expert systems in space p 111 A87-32075
An evaluation of menu systems for Space Station interfaces p 111 A87-33040
Data capture and processing --- for Space Station [AIAA PAPER 87-2203] p 113 A87-48588
ESA software engineering standards for future programmes [AIAA PAPER 87-2207] p 154 A87-48592
Standards for the user interface - Developing a user consensus --- for Space Station Information System [AIAA PAPER 87-2209] p 169 A87-48594
The hardware/software architecture of the Columbus pressurized module element [AIAA PAPER 87-2211] p 154 A87-48596
Evolution of data management systems from Spacelab to Columbus [AIAA PAPER 87-2227] p 154 A87-48605
Flight array processor p 116 N87-29148
Fiber optics wavelength division multiplexing(components) p 117 N87-29151
AIRCRAFT CONSTRUCTION MATERIALS
Computerized aerospace materials data; Proceedings of the Workshop on Computerized Property Materials and Design Data for the Aerospace Industry, El Segundo, CA, June 23-25, 1986 p 111 A87-35262
AIRCRAFT CONTROL
Control operations in advanced aerospace systems p 54 A87-32117
AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volumes 1 & 2 p 60 A87-50401
Singular perturbation analysis of AOTV related trajectory optimization problems [NASA-CR-180301] p 137 N87-26927
AIRCRAFT GUIDANCE
AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volumes 1 & 2 p 60 A87-50401
AIRCRAFT NOISE
Documentation of the space station/aircraft acoustic apparatus [NASA-TM-89111] p 140 N87-20795
AIRCRAFT STRUCTURES
Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Parts 2A & 2B p 15 A87-33654
ALGAE
The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325
ALGORITHMS
Practical implementation of an accurate method for multilevel design sensitivity analysis [AIAA PAPER 87-0718] p 6 A87-33560
Proposed CMG momentum management scheme for space station [AIAA PAPER 87-2528] p 62 A87-50531
The multi-disciplinary design study. A life cycle cost algorithm [NASA-CR-178192] p 9 N87-21995
Large space structures ground experiment checkout p 30 N87-22704
Identification of large space structures: A state-of-practice report p 31 N87-22705
Flexible spacecraft simulator p 31 N87-22718
Moving-bank multiple model adaptive estimation applied to flexible spacestructure control [AD-A178870] p 68 N87-22761
An integrated, optimization-based approach to the design and control of large space structures [AD-A179459] p 34 N87-23683
Large spacecraft pointing and shape control p 69 N87-24496
Distributed control using linear momentum exchange devices [NASA-TM-100308] p 70 N87-24521
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems [NASA-CR-181156] p 36 N87-25605
Projection filters for modal parameter estimate for flexible structures [NASA-CR-180303] p 38 N87-26583
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures [AD-A183302] p 11 N87-29893
ALKALINE BATTERIES
Advanced technology for extended endurance alkaline fuel cells p 75 A87-33787
Development of an alkaline fuel cell subsystem [NASA-CR-172002] p 81 N87-29188
ALTERNATING CURRENT
20 kHz Space Station power system p 76 A87-40378
ALUMINUM
Comparison of satellite support structure aluminum versus graphite epoxy [SAWE PAPER 1692] p 20 A87-36279
ALUMINUM ALLOYS
Material damping in aluminum and metal matrix composites p 106 A87-44797
ALUMINUM COATINGS
Microcrack resistant structural composite tubes for space applications p 136 A87-41022
ALUMINUM GRAPHITE COMPOSITES
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results [AIAA PAPER 87-2157] p 160 A87-45441
Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries p 107 A87-51772
AMINES
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
AMMONIA
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR) [SAE PAPER 860985] p 50 A87-38784
ANALOG SIMULATION
The effect of nonlinearities on flexible structures [AD-A181735] p 38 N87-27259
ANGULAR ACCELERATION
Tracking and pointing maneuvers with slew-excited deformation shaping [AIAA PAPER 87-2589] p 62 A87-50561
ANGULAR MOMENTUM
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment p 148 A87-34207
Dynamics of gyroelastic spacecraft p 59 A87-47811
Proposed CMG momentum management scheme for space station [AIAA PAPER 87-2528] p 62 A87-50531
Adaptive momentum management for the dual keel Space Station [AIAA PAPER 87-2596] p 62 A87-50558
Space station momentum management p 64 N87-20868
ANGULAR VELOCITY
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22706
ANIMALS
Plant and animal accommodation for Space Station Laboratory [SAE PAPER 860975] p 124 A87-38757
ANISOTROPIC MEDIA
Localization in disordered periodic structures [AIAA PAPER 87-0819] p 19 A87-33757
ANTENNA ARRAYS
The evolution of the geostationary platform concept p 125 A87-43154
ANTENNA COMPONENTS
Design considerations for a one-kilometer antenna stick [AIAA PAPER 87-0871] p 15 A87-33635
Composite space antenna structures - Properties and environmental effects p 20 A87-38610
ANTENNA DESIGN
Design considerations for a one-kilometer antenna stick [AIAA PAPER 87-0871] p 15 A87-33635
Box truss antenna technology status p 87 N87-24503
ANTENNA RADIATION PATTERNS
Shape control of the directional pattern in a microwave-beam power transmission channel p 148 A87-34345
Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit [NASA-TM-89118] p 86 N87-20339
Hoop/column and tetrahedral truss electromagnetic tests p 87 N87-24504
ANTENNAS
Measurement apparatus and procedure for the determination of surface emissivities [NASA-CASE-LAR-13455-1] p 29 N87-21206
Technology for Large Space Systems. A bibliography with indexes (supplement 17) [NASA-SP-7046(17)] p 39 N87-29576
ANTIMATTER
Advanced propulsion activities in the USA p 90 A87-41575
APPLICATIONS PROGRAMS (COMPUTERS)
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [AIAA PAPER 87-1764] p 92 A87-48572
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction p 9 N87-22735
High speed simulation of flexible multibody dynamics p 33 N87-22736
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [NASA-TM-89921] p 96 N87-22949
TAE Plus: A conceptual view of TAE in the space station era p 9 N87-23157
SOT: A rapid prototype using TAE windows p 114 N87-23161
Development of an emulation-simulation thermal control model for space station application [NASA-CR-180312] p 45 N87-26936
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures --- spacecraft masts [NASA-CR-180317] p 38 N87-27260
Development of an emulation-simulation thermal control model for space station application [NASA-CR-181221] p 45 N87-27702
APPROPRIATIONS
National Aeronautics and Space Administration Authorization Act [S-REPT-100-87] p 171 N87-24240
National Aeronautics and Space Administration Authorization Act, fiscal year 1988 [H-REPT-100-204] p 171 N87-25024
NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988 [GPO-73-245] p 172 N87-30221
APSIDES
Orbital modifications using forced tether-length variations p 124 A87-40858
ARCHITECTURE
Space station group activities habitability module study [NASA-CR-4010] p 165 N87-21585
ARCHITECTURE (COMPUTERS)
System architecture for the telerobotic work system [AAS PAPER 86-044] p 99 A87-32746
The hardware/software architecture of the Columbus pressurized module element [AIAA PAPER 87-2211] p 154 A87-48596
Space operations: NASA's use of information technology. Report to the Chairman, Committee on Science, Space and Technology [GAO/IMTEC-87-20] p 137 N87-22551
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) docking-undocking phases). Architecture of the whole simulator, volume 2 [LP-RP-AI-204-VOL-2] p 68 N87-24480
Mass storage systems for data transport in the early space station era 1992-1998 [NASA-TM-87826] p 115 N87-27443
Automated Subsystem Control for Life Support System (ASCLSS) [NASA-CR-172003] p 53 N87-29117
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1 [NASA-TM-89285] p 116 N87-29124
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2 [NASA-TM-89286] p 116 N87-29144
MAX: A space station computer option p 116 N87-29146
Fiber optic data systems p 117 N87-29152
User data management p 4 N87-29163
ARIANE LAUNCH VEHICLE
The European space programme p 150 A87-37962
Ariane transfer vehicle (ATV) to supply Space Station [AIAA PAPER 87-1962] p 152 A87-45257
ARM (ANATOMY)
A comparison between space suited and unsuited reach envelopes p 47 A87-33013
Desirability of arms-in capability in space suits [SAE PAPER 860951] p 49 A87-36730
ARMED FORCES (UNITED STATES)
Military man in space: A history of Air Force efforts to find a manned space mission [AD-A179873] p 171 N87-25815
ARRAYS
Maximum likelihood identification using an array processor p 5 A87-32121

Performance characteristics of a combination solar photovoltaic heat engine energy converter
[NASA-TM-89908] p 78 N87-23028
ARTIFICIAL GRAVITY
A question of gravity p 1 A87-32116
ARTIFICIAL INTELLIGENCE
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
Space Station autonomy - What are the challenges? How can they be met? p 101 A87-53059
Study of expert system applications to space projects
[NE-51-867] p 115 N87-26057
ARTIFICIAL SATELLITES
Satellite servicing mission preliminary cost estimation model
[NASA-CR-171978] p 136 N87-20335
Low frequency vibration testing on satellites
p 27 N87-20364
ASSAYING
Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2308] p 158 N87-27698
ASTRODYNAMICS
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32729
Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25355
ASTROMETRY
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222
An astrometric facility for planetary detection on the Space Station p 127 A87-50753
An astrometric facility for planetary detection on the space station
[NASA-TM-89436] p 128 N87-20841
Astronomic Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description
[NASA-TM-89429-VOL-2] p 129 N87-22570
Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary
[NASA-TM-89429-VOL-1] p 129 N87-22571
ASTRONAUT PERFORMANCE
Desirability of arms-in capability in space suits
[SAE PAPER 860951] p 49 A87-38738
The development of an EVA Universal Work Station
[SAE PAPER 860952] p 164 A87-38739
Physiological aspects of EVA
[SAE PAPER 860991] p 164 A87-38768
Advanced orbital servicing capabilities development
[SAE PAPER 860992] p 134 A87-38769
The next step for the MMU - Capabilities and enhancements
[SAE PAPER 861013] p 160 A87-38783
ASTRONAUTICS
International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volumes 1 & 2 p 156 A87-32276
EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 p 2 A87-40351
Space: New opportunities for all people; Selected Proceedings of the Thirty-seventh International Astronautical Congress, Innsbruck, Austria, Oct. 4-11, 1986 p 168 A87-41568
The Gagarin scientific lectures in astronautics and aviation, 1985 — Russian book p 152 A87-42923
The Gagarin Scientific Lectures on Astronautics and Aviation, 1986 — Book p 169 A87-51869
ASTRONAUTS
Living in space: A handbook for space travellers
p 162 A87-33475
The station is raising lots of questions about space law p 167 A87-34597
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
Dynamic behavior of astronauts and satellites outside an orbiting space station under the influence of thrust
p 52 A87-41666
The astronaut and the robot - Short- and long-term scenarios for space technology p 101 A87-53061
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A178997] p 120 N87-22762
Bi-stem gripping apparatus
[NASA-CASE-MFS-28185-1] p 107 N87-21586
ASTRONOMICAL OBSERVATORIES
'HEXE' - X-ray observatory in space
p 155 A87-53558
ASTRONOMICAL PHOTOGRAPHY
Qualification of the faint object camera
p 127 N87-20359
ASTRONOMY
Prospects for space science
[AAS PAPER 86-106] p 170 A87-53065
ASTROPHYSICS
Astronomic Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description
[NASA-TM-89429-VOL-2] p 129 N87-22570
Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary
[NASA-TM-89429-VOL-1] p 129 N87-22571
USSR Report: Space
[JPRS-USP-86-004] p 158 N87-27567
ATMOSPHERIC DENSITY
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations
[NASA-CP-2460] p 64 N87-20665
Density uncertainty effect on cost of space station reboost p 170 N87-20667
Space station momentum management
p 64 N87-20668
Aero-Assisted Orbital Transfer Vehicle (AOTV)
p 3 N87-20682
ATMOSPHERIC EFFECTS
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47809
ATMOSPHERIC MODELS
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations
[NASA-CP-2460] p 64 N87-20665
ATMOSPHERIC SOUNDING
Report of the atmosphere panel p 161 N87-20633
ATOMIC BEAMS
The Vanderbilt University neutral O-beam facility
p 105 A87-32059
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies
p 105 A87-32060
Martin Marietta atomic oxygen beam facility
p 139 A87-38622
A high flux pulsed source of energetic atomic oxygen — for spacecraft materials ground testing
p 139 A87-38623
Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-38624
Production of pulsed atomic oxygen beams via laser vaporization methods p 106 A87-38625
Variable energy, high flux, ground-state atomic oxygen source
[NASA-CASE-NPO-16640-1-CU] p 8 N87-21661
Proceedings of the NASA Workshop on Atomic Oxygen Effects — low earth orbital environment
[NASA-CR-181163] p 141 N87-26173
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-26186
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 131 N87-26188
Pulsed source of energetic atomic oxygen
p 108 N87-26189
Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26190
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-26191
Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26200
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-26204
ATS 6
Automatic charge control system for geosynchronous satellites p 87 N87-29880
ATTENUATORS
An electromechanical attenuator/actuator for Space Station docking p 136 N87-29878
ATTITUDE (INCLINATION)
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment
p 148 A87-34207
ATTITUDE CONTROL
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731
A study on singularity of single gimbal CMG systems
p 149 A87-35077
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46793
Robust nonlinear attitude control of flexible spacecraft
p 60 A87-48273
On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2459] p 61 A87-50505
Propellant tank resupply system
[AD-D012559] p 80 N87-20375
One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
Dual keel space station control/structures interaction study p 67 N87-22737
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
Automatic docking maneuver and attitude control system p 71 N87-25395
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary — laboratory test model
[ESA-CR(P)-2361-VOL-1] p 73 N87-27707
Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report — laboratory test model
[ESA-CR(P)-2361-VOL-2] p 73 N87-27708
Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2361-VOL-4] p 73 N87-27709
ATTITUDE STABILITY
Dynamic and thermal effects in very large space structures p 25 N87-20347
An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A179236] p 68 N87-23681
AURORAL IRRADIATION
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved
p 142 N87-26849
AURORAL ZONES
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved
p 142 N87-26849
AUTOCODERS
Automated software production
[AIAA PAPER 87-2219] p 2 A87-48601
AUTOMATIC CONTROL
Control operations in advanced aerospace systems
p 54 A87-32117
Variable structure controller design for spacecraft nutation damping p 58 A87-39958
Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-48156
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412
Automated Subsystem Control for Life Support System (ASCLSS)
[NASA-CR-172003] p 53 N87-29117
The preloadable vector sensitive latch for orbital docking/berthing p 162 N87-29876
AUTOMATIC PILOTS
Mass property estimation for control of asymmetrical satellites p 63 A87-52998
AUTOMATION
Overview of the NASA automation and robotics research program p 100 A87-33867
Manned spacecraft automation and robotics
p 100 A87-37300
Life Sciences Research Facility automation requirements and concepts for the Space Station
[SAE PAPER 860970] p 50 A87-38752
Planning for space robotics developments and applications p 135 A87-40377
Space: New opportunities for all people; Selected Proceedings of the Thirty-seventh International Astronautical Congress, Innsbruck, Austria, Oct. 4-11, 1986 p 168 A87-41568
Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-48595
AUTONOMY
Autonomous decentralized system concept for Space Station p 148 A87-32541
A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system
[AIAA PAPER 87-2467] p 77 A87-50511
Space Station autonomy - What are the challenges? How can they be met? p 101 A87-53059
Self-calibration strategies for robot manipulators
p 102 N87-26355
AUXILIARY PROPULSION
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 80 A87-50197

Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 96 N87-23821

AVIONICS
Space Station integration and verification concepts
p 84 A87-31461
System level verification applying the Space Shuttle experience to the Space Station
[AAS PAPER 86-001] p 55 A87-32727

AXES (REFERENCE LINES)
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373

AXIAL COMPRESSION LOADS
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads
[AIAA PAPER 87-0877] p 105 A87-33639

AXIAL STRESS
Analytical solutions for static elastic deformations of wire ropes
[AIAA PAPER 87-0720] p 6 A87-33561

B

BACTERIAL DISEASES
Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26703

BALL BEARINGS
Development of harmonic drive actuator for space manipulator p 149 A87-35076

BALLISTIC VEHICLES
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-11573

BAYES THEOREM
A computer program for model verification of dynamic systems p 31 N87-22710

BAYS (STRUCTURAL UNITS)
Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21158
Deployable geodesic truss structure
[NASA-CASE-LAR-13113-1] p 36 N87-25492

BEAM CURRENTS
Electron beam experiments at high altitudes
p 142 N87-26946

BEAMS (SUPPORTS)
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548
Identification of the zero-g shape of a space beam
[AIAA PAPER 87-0872] p 15 A87-33636
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads
[AIAA PAPER 87-0877] p 105 A87-33639
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
Control of flexible structures by applied thermal gradients p 21 A87-39543
Modeling, stabilization and control of serially connected beams p 21 A87-41052
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
Verification of large beam-type space structures
p 31 N87-22712
Dynamics of trusses having nonlinear joints
p 32 N87-22724
Design, development and fabrication of a deployable/retractable truss beam model for large space structures application
[NASA-CR-178287] p 35 N87-25349
Bi-stem gripping apparatus
[NASA-CASE-MFS-28185-1] p 107 N87-25586
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29713
The design and development of a two-dimensional adaptive truss structure p 40 N87-29860
Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-29896

BEARINGS
A hybrid nonlinear programming method for design optimization p 7 A87-35716

BENDING
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 168 A87-25396

BENDING MOMENTS
A new approach for vibration control in large space structures p 33 N87-22743

BENDING VIBRATION
Control of a flexible space manipulator
p 90 A87-32449
Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22726

BIBLIOGRAPHIES
Space station systems: A bibliography with indexes (supplement 4)
[NASA-SP-7056(04)] p 4 N87-26073
Technology for Large Space Systems. A bibliography with indexes (supplement 17)
[NASA-SP-7046(17)] p 39 N87-29576

BINDERS (MATERIALS)
Space Station lubrication considerations
p 104 N87-29879

BIOASSAY
Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26703
Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2336] p 158 N87-27898

BIOASTRONAUTICS
Space Station - Opportunities for the life sciences
p 122 A87-34871
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-38757
Life support subsystem concepts for botanical experiments of long duration
[MBB-UR-E-907-86-PUB] p 154 A87-49967
The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53062

BIOCHEMISTRY
Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2336] p 158 N87-27898

BIODYNAMICS
A comparison between space suited and unsuited reach envelopes p 47 A87-33013
U.S. National Congress of Applied Mechanics, 10th, University of Texas, Austin, June 16-20, 1986, Proceedings
[AD-A181952] p 1 A87-40051
Effect of crew motions on the spatial position of a spacecraft p 152 A87-41954

BIOLOGICAL MODELS (MATHEMATICS)
ISOKIN - A quantitative model of the kinesthetic aspects of spatial habitability p 162 A87-33002

BLACK BRANT SOUNDING ROCKETS
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521

BODY KINEMATICS
Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33728

BODY MEASUREMENT (BIOLOGY)
Space suit reach and strength envelope considerations
[SAE PAPER 860950] p 49 A87-38737

BOILING
Determination of the cross-sectional temperature distribution and boiling limitation of a heat pipe
p 40 A87-32175

BONDING
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29713

BOOMS (EQUIPMENT)
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25355
Dynamic analysis of the flexible boom in the N-ROSS satellite
[AD-A181458] p 72 N87-26986
Computer simulation of a rotational single-element flexible spacecraft boom
[AD-A181798] p 103 N87-26868
Folding, articulated, square truss p 40 N87-29859

BOTANY
Life Support Subsystem concepts for botanical experiments of long duration
[SAE PAPER 860967] p 49 A87-38749
Life support subsystem concepts for botanical experiments of long duration
[MBB-UR-E-907-86-PUB] p 154 A87-49967
Botanical payloads for platforms and space stations
[MBB-UR-E-921/86] p 158 N87-25340

BOUNDARY VALUE PROBLEMS
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33670
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739
A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731
A new approach for vibration control in large space structures p 33 N87-22743
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712

BRAKING
Common drive unit p 104 N87-29869

BRAYTON CYCLE
Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system
[SAE PAPER 860999] p 43 A87-38776
Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-89863] p 121 N87-23674

BREMSSTRAHLUNG
High energy gamma ray astronomy
p 129 N87-24258

BUBBLES
Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation
[AIAA PAPER 87-2021] p 92 A87-45360

BUCKLING
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads
[AIAA PAPER 87-0877] p 105 A87-33639

C

CABIN ATMOSPHERES
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station
p 46 A87-32544

CABLES (ROPES)
Analytical solutions for static elastic deformations of wire ropes
[AIAA PAPER 87-0720] p 6 A87-33561
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180698] p 28 N87-20569

CALIBRATING
Panel report on new approaches to calibration and validation — Columbus polar platforms
p 157 N87-20638
Mass spectrometers and atomic oxygen
p 141 N87-26176
Self-calibration strategies for robot manipulators
p 102 N87-26355
Absolute indoor calibration of large area solar cells
p 159 N87-29015

CANADIAN SPACE PROGRAM
The Canadian space program p 143 A87-32281
The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 100 A87-41153
The Space Station overview p 168 A87-41571

CANTILEVER BEAMS
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32120
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711

CARBON
Laboratory studies of atomic oxygen reactions with solids p 4 N87-26185

CARBON DIOXIDE CONCENTRATION
EDC development and testing for the Space Station program — Electrochemical Carbon Dioxide Concentration
[SAE PAPER 860918] p 118 A87-38710

CARBON DIOXIDE REMOVAL
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32458
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station
p 46 A87-32544
An advanced carbon reactor subsystem for carbon dioxide reduction
[SAE PAPER 860995] p 51 A87-38772
Complex system monitoring and fault diagnosis using communicating expert systems p 118 A87-40363

CARBON FIBER REINFORCED PLASTICS
Carbon fibre slotted waveguide arrays
p 85 A87-41302
PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44588
Development of full scale deployable CFRP truss for space structure p 25 A87-51793

CARBON FIBERS
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182931] p 110 N87-29709

CARBON-CARBON COMPOSITES
Evaluation of carbon-carbon for space engine nozzle p 96 N87-26116
CARGO SPACECRAFT
Mir in action p 150 A87-37971
CASSEGRAIN ANTENNAS
On-board K- and S-band multi-beam antennas p 86 A87-46281
CATHODE RAY TUBES
Head-ported display analysis for Space Station applications p 111 A87-31463
CENTER OF GRAVITY
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32815
Space station control moment gyro control p 64 N87-20669
CENTER OF MASS
Mass property estimation for control of asymmetrical satellites p 63 A87-52968
CENTER OF PRESSURE
Space station control moment gyro control p 64 N87-20669
CENTRAL PROCESSING UNITS
A VHSIC general purpose processor p 116 N87-29145
CENTRIFUGES
Special considerations in outfitting a space station module for scientific use [SAE PAPER 860956] p 164 A87-38741
CHALLENGER (ORBITER)
Space Shuttle flight rates and utilization p 1 A87-37963
CHANNELS (DATA TRANSMISSION)
Star topology spacecraft data bus p 112 A87-37431
SS focused technology: Gateways and NOS's p 117 N87-29165
Network operating system p 117 N87-29166
CHARGE EXCHANGE
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation p 131 N87-26166
CHARGE TRANSFER
Investigation of plasma contactors for use with orbiting wires [NASA-CR-180922] p 129 N87-22509
CHARGED PARTICLES
Documentation for the SHADO particle wake routine [AD-A181531] p 131 N87-26967
CHEMICAL EFFECTS
Oxygen interaction with space-power materials [NASA-CR-181398] p 132 N87-29633
CHEMICAL REACTIONS
Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-26179
CHEMICAL REACTORS
An advanced carbon reactor subsystem for carbon dioxide reduction [SAE PAPER 860995] p 51 A87-38772
CIRCUIT PROTECTION
Electrostatic immunity of geostationary satellites p 143 N87-26957
CIRCULAR PLATES
Vibrations and structureborne noise in space station [NASA-CR-181341] p 39 N87-29590
CIRCULATION
Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47612
CIVIL AVIATION
Toward the year 2000: The near future of the American civilian and military space programs [DE87-006457] p 171 N87-22607
CLOSED CYCLES
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs [SAE PAPER 860987] p 51 A87-38766
Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system [SAE PAPER 860999] p 43 A87-38776
CLOSED ECOLOGICAL SYSTEMS
Water recycling for Space Station p 46 A87-32458
CELSS waste management systems evaluation [SAE PAPER 860997] p 51 A87-38774
Life support subsystem concepts for botanical experiments of long duration [MBB-UR-E-907-86-PUB] p 154 A87-49967
Electrochemical processing of solid waste [NASA-CR-181126] p 137 N87-25443
A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications [NASA-CR-177447] p 130 N87-25767
Space station propulsion-ECLSS interaction study [NASA-CR-179060] p 54 N87-29584
CLOUDS
External contamination environment of Space Station Customer Servicing Facility [AIAA PAPER 87-1623] p 52 A87-43122
COATINGS
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment [AD-A182931] p 110 N87-29709
COAXIAL CABLES
Coaxial tube array space transmission line characterization [NASA-TM-89864] p 96 N87-22003
CODING
Coded mask telescopes for X-ray astronomy p 123 A87-37765
COLD SURFACES
Design of an advanced two-phase capillary cold plate [SAE PAPER 861829] p 41 A87-32663
COLLIMATION
Carbon fibre slotted waveguide arrays p 85 A87-41302
COLUMBUS SPACE STATION
Ariane transfer vehicle (ATV) to supply Space Station [AIAA PAPER 87-1862] p 152 A87-45257
Columbus pressurized modules p 153 A87-46945
Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems [AIAA PAPER 87-2210] p 154 A87-48595
The hardware/software architecture of the Columbus pressurized module element [AIAA PAPER 87-2211] p 154 A87-48596
Evolution of data management systems from Spacelab to Columbus [AIAA PAPER 87-2227] p 154 A87-48605
The Columbus system baseline and interfaces p 156 A87-53923
The Columbus program p 157 N87-25031
Botanical payloads for platforms and space stations [MBB-UR-E-921/86] p 158 N87-25340
Possibilities of the further development of Columbus to an autonomous European space station [MBB-UR-E-922/86] p 158 N87-25418
COMBUSTION PRODUCTS
Hydrogen-oxygen thruster with no products of combustion in exhaust plume [AIAA PAPER 87-1775] p 91 A87-45196
COMMAND AND CONTROL
System architecture for the telerobotic work system [AAS PAPER 86-044] p 99 A87-32746
User interface and payload command and control p 73 N87-29162
COMMERCE
Remote sensing applications: Commercial issues and opportunities for space station — SPOT p 156 N87-20626
COMMERCIAL SPACECRAFT
Commercialization of space - The insurance implications p 166 A87-32460
The Industrial Space Facility p 167 A87-38579
COMMUNICATION NETWORKS
The effect of multipath on digital communications systems: With application to space station [AD-A178578] p 86 N87-22676
Integration of communications and tracking data processing simulation for space station p 115 N87-25890
Network reliability p 117 N87-29157
COMMUNICATION SATELLITES
Precise pointing control of flexible spacecraft p 55 A87-32446
Communication missions for geostationary platforms p 84 A87-34797
Modal-survey testing of the Olympus spacecraft p 152 A87-42298
Japan's space development programs for communications - An overview p 152 A87-43156
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-46662
Comparison of different attitude control schemes for large communications satellites [AIAA PAPER 87-2381] p 61 A87-50475
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 86 N87-20360
Modal testing of the Olympus development model stowed solar array p 27 N87-20366
Plans for industrialization of space discussed p 157 N87-21979
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit p 158 N87-26953
COMPARISON
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment [AD-A179106] p 161 N87-23677
COMPARTMENTS
Prototype thermal bus for manned Space Station compartments [SAE PAPER 861825] p 41 A87-32666
COMPENSATORS
Integrated control/structure design and robustness p 65 N87-22060
COMPILERS
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155
COMPLEX SYSTEMS
Problems of mechanical system configuration control p 149 A87-35877
COMPONENT RELIABILITY
Evaluation testing of a mechanical actuator component operating in a simulated space environment p 160 A87-32549
COMPOSITE MATERIALS
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings p 167 A87-38576
Assessment of space environment induced microdamage in toughened composite materials p 20 A87-38609
Use of lightweight composites for GAS payload structures p 25 N87-20307
Dynamic analysis of the flexible boom in the N-ROSS satellite [AD-A181488] p 72 N87-26966
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment [AD-A182931] p 110 N87-29709
COMPOSITE STRUCTURES
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads [AIAA PAPER 87-0877] p 105 A87-33639
Dynamic response of a viscoelastic Timoshenko beam [AIAA PAPER 87-0890] p 16 A87-33708
Composite tubes for the Space Station truss structure p 20 A87-38601
Composite space antenna structures - Properties and environmental effects p 20 A87-38610
Measuring thermal expansion in large composite structures — for spaceborne telescopes p 20 A87-38612
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results [AIAA PAPER 87-2157] p 160 A87-45441
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327
Stress and deformation analysis of lightweight composite structures — space antennas [MBB-UD-489/86] p 30 N87-22269
COMPRESSION LOADS
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell [NASA-TM-100102] p 79 N87-24838
COMPUTATION
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures [AD-A183302] p 11 N87-29893
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures [NASA-CR-4099] p 40 N87-29699
COMPUTATIONAL CHEMISTRY
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules p 108 N87-26182
Potential surfaces for O atom-polymer reactions p 109 N87-26201
COMPUTATIONAL GRIDS
Radiation heat transfer calculations for space structures [AIAA PAPER 87-1522] p 44 A87-44830
An overview of controls research on the NASA Langley Research Center grid p 66 N87-22720
COMPUTER AIDED DESIGN
ASTROS - A multidisciplinary automated structural design tool [AIAA PAPER 87-0713] p 6 A87-33557
A hybrid nonlinear programming method for design optimization p 7 A87-35718
Gradient-based combined structural and control optimization p 21 A87-40866
Interdisciplinary analysis procedures in the modeling and control of large space-based structures p 22 A87-42678
Box truss antenna technology status p 67 N87-24503

COMPUTER GRAPHICS
Engineering graphics and image processing at Langley Research Center p 10 N87-29129
COMPUTER NETWORKS
Network operating system focus technology
p 117 N87-29167
COMPUTER PROGRAM INTEGRITY
Automated software production
[AIAA PAPER 87-2219] p 2 A87-48601
COMPUTER PROGRAMMING
Automated software production
[AIAA PAPER 87-2219] p 2 A87-48601
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155
COMPUTER PROGRAMS
MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32639
ASTROS - A multidisciplinary automated structural design tool
[AIAA PAPER 87-0713] p 6 A87-33557
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 6 A87-33560
Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-20581
The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178182] p 9 N87-21995
Microprocessor controlled proof-mass actuator
p 65 N87-22706
Box truss antenna technology status
p 87 N87-24503
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-26698
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182589] p 81 N87-28186
SS focused technology: Gateways and NOS's
p 117 N87-29165
COMPUTER SYSTEMS DESIGN
Data capture and processing — for Space Station
[AIAA PAPER 87-2203] p 113 A87-48588
Standards for the user interface - Developing a user consensus — for Space Station Information System
[AIAA PAPER 87-2209] p 169 A87-48594
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2
[LP-RP-AI-204-VOL-2] p 68 N87-24490
Data management system architecture options for space stations — Columbus project
[SES/DNP/TR/002/85] p 115 N87-28585
Study of data management system architecture options for space station — Columbus project
[MATRA-RF/176/0932-ISS-1] p 115 N87-28586
A workstation environment for software engineering
p 116 N87-29128
Advanced software tools space station focused technology p 5 N87-29164
Network operating system focus technology
p 117 N87-29167
COMPUTER SYSTEMS PERFORMANCE
On the performance analysis of a real-time distributed computer system p 111 A87-31518
Space station data management system - A common GSE test interface for systems testing and verification
p 112 A87-37294
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24491
COMPUTER SYSTEMS PROGRAMS
The Space Station software support environment - Not just what, but why
[AIAA PAPER 87-2208] p 114 A87-48593
Standards for the user interface - Developing a user consensus — for Space Station Information System
[AIAA PAPER 87-2209] p 169 A87-48594
TAE Plus: A conceptual view of TAE in the space station era p 9 N87-23157
SOT: A rapid prototype using TAE windows
p 114 N87-23161
COMPUTER TECHNIQUES
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A178867] p 120 N87-22762
COMPUTER VISION
Optical correlator use at Johnson Space Center
p 59 A87-42655
COMPUTERIZED SIMULATION
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533
Computer simulation of on-orbit manned maneuvering unit operations
[SAE PAPER 861783] p 47 A87-32632
Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33687
Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33728
Real-time simulation for Space Station
p 7 A87-37298
Orbital modifications using forced tether-length variations p 124 A87-43658
Orbital debris environment resulting from future activities in space p 139 A87-44392
On the inadequacies of current multi-flexible body simulation codes
[AIAA PAPER 87-2248] p 7 A87-50412
A laboratory simulation of flexible spacecraft control
[AIAA PAPER 87-2325] p 24 A87-50446
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 93 A87-52247
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721
Impact of space station appendage vibrations on the pointing performance of gimballed payloads
p 32 N87-22733
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 9 N87-22735
High speed simulation of flexible multibody dynamics
p 33 N87-22738
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24491
Integration of communications and tracking data processing simulation for space station
p 115 N87-25690
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-26698
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-26036
Computer simulation of a rotational single-element flexible spacecraft boom
[AD-A181798] p 103 N87-26968
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182589] p 81 N87-28186
Computer simulation of deployment — solar arrays
p 10 N87-29002
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-29581
CONCENTRATORS
GaAs concentrator solar arrays p 82 N87-28977
CONDENSATION
Mixing-induced ullage condensation and fluid destratification
[AIAA PAPER 87-2018] p 92 A87-45357
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
CONDENSERS (LIQUEFIERS)
High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-52377
CONFERENCES
International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volumes 1 & 2 p 166 A87-32276
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p 182 A87-33001
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p 15 A87-33654
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p 123 A87-38567
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[SAE P-177] p 162 A87-38701
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[AD-A181862] p 1 A87-40051
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Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A175529] p 26 N87-20355
The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Blast and Ground Shock, Shock Testing and Analysis
[AD-A175224] p 29 N87-20574
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[ESA-SP-266] p 126 N87-20621
Microgravity Fluid Management Symposium
[NASA-CP-2465] p 94 N87-21141
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 66 N87-22729
Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354
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[NASA-CR-181163] p 141 N87-26173
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26937
Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-26958
CONFIGURATION MANAGEMENT
Problems of mechanical system configuration control
p 149 A87-35877
The design and development of a two-dimensional adaptive truss structure p 40 N87-29880
CONGRESSIONAL REPORTS
Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-73-418] p 171 N87-22580
National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240
National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-25024
National Aeronautics and Space Administration
p 172 N87-30220
NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988
[GPO-73-245] p 172 N87-30221
CONNECTORS
Collect lock joint for space station truss
[NASA-CASE-MSC-21207-1] p 38 N87-25576
Development of a standard connector for orbital replacement units for serviceable spacecraft
p 40 N87-29864
CONSTRAINTS
Structural optimization with frequency constraints
[AIAA PAPER 87-0787] p 13 A87-33586

CONSTRUCTION MATERIALS
Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 p 13 A87-33551
CONTACTORS
Hollow cathode-based plasma contactor experiments for electrodynamic tether
[AIAA PAPER 87-0572] p 121 A87-32192
Theory of plasma contactors for electrodynamic tethered satellite systems p 85 A87-41609
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-29591
CONTINUUM MECHANICS
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33564
Modeling and control of flexible structures
[AD-A177108] p 29 N87-21398
Equivalent beam modeling using numerical reduction techniques p 32 N87-22725
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179726] p 35 N87-24517
CONTINUUM MODELING
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts
p 19 A87-35327
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-46121
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 30 N87-22258
CONTRACTS
Space Station business p 169 A87-47726
CONTROL
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570
CONTROL CONFIGURED VEHICLES
Control operations in advanced aerospace systems
p 54 A87-32117
An assessment of recent advances in modeling and control design of space structures under uncertainty
[SAE PAPER 861818] p 147 A87-32655
Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32657
Static shape control for flexible structures
[SAE PAPER 861822] p 13 A87-33553
Vibration suppression using a constrained rate-feedback Threshold control strategy — for large space structures
[AIAA PAPER 87-0741] p 5 A87-33655
Structural and control optimization of space structures
[AIAA PAPER 87-0839] p 17 A87-33731
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46793
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47809
Robust multivariable control of large space structures using positivity p 59 A87-47810
CONTROL EQUIPMENT
An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579
Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 89 A87-36776
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 861007] p 52 A87-36779
Status report and preliminary results of the spacecraft control laboratory experiment p 66 N87-22717
End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC) — in-orbiting servicing
[FOK-TR-R-86-091-VOL-2] p 102 N87-24486
End effector development study, volume 1 — in-orbit servicing
[FOK-TR-R-86-091-VOL-1] p 102 N87-25336
End effector development study. Volume 3: Appendices — in-orbit servicing
[FOK-TR-R-86-091-VOL-3] p 102 N87-25337
CONTROL MOMENT GYROSCOPES
A highly adaptable steering/selection procedure for combined CMG/RCS spacecraft control
[AAS PAPER 86-036] p 56 A87-32741
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531
Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2596] p 62 A87-50558
Space station momentum management
p 64 N87-20668
Space station control moment gyro control
p 64 N87-20669
CONTROL SIMULATION
A laboratory simulation of flexible spacecraft control
[AIAA PAPER 87-2325] p 24 A87-50446
Control/dynamics simulation for preliminary Space Station design
[AIAA PAPER 87-2641] p 61 A87-50486
Flexible spacecraft simulator p 31 N87-22718
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2
[LP-RP-AI-204-VOL-2] p 69 N87-24490
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24491
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Docking-undocking phase analysis
[LP-RP-AI-204-VOL-1] p 70 N87-24514
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25356
Active vibration damping of flexible structures using the traveling wave approach p 71 N87-25360
Automatic docking maneuver and attitude control system p 71 N87-25395
CONTROL STABILITY
Robustness optimization of structural and controller parameters
[AIAA PAPER 87-0791] p 14 A87-33591
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 9 N87-22716
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
NASA/DOD Control/Structures Interaction Technology, 1986
[NASA-CP-2447-PT-2] p 34 N87-24495
Joint Optics Structures Experiment (JOSE)
p 34 N87-24497
Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29868
CONTROL SYSTEMS DESIGN
Robust controller design using frequency domain constraints p 11 A87-32229
Robust controller synthesis for a large flexible space antenna p 84 A87-32235
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236
Transient dynamics of orbiting flexible structural members p 54 A87-32338
High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-32377
Local control for large space structures
p 54 A87-32440
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443
Vibration control for a linked system of flexible structures p 55 A87-32444
Precise pointing control of flexible spacecraft
p 55 A87-32446
Control of a flexible space manipulator
p 99 A87-32449
An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579
Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32657
The Softmounted Inertially Reacting Pointing System (SIRPNT)
[AAS PAPER 86-007] p 56 A87-32732
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32736
Laser docking system flight experiment
[AAS PAPER 86-043] p 99 A87-32745
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 56 A87-33572
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33610
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295
System aspects of Columbus thermal control
[SAE PAPER 860936] p 150 A87-36727
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-36729
Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 48 A87-36730
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements
[SAE PAPER 860945] p 48 A87-36732
Evaluation of Space Station thermal control techniques
[SAE PAPER 860998] p 42 A87-36775
Variable structure controller design for spacecraft nutation damping p 58 A87-39958
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42817
Space station active thermal control system modelling
[AIAA PAPER 87-1468] p 43 A87-43003
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
Construction of positive real compensation for LSS control — applied to Large Space Structure model
[AIAA PAPER 87-2238] p 60 A87-50404
Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2250] p 60 A87-50414
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 60 A87-50415
Robust control of a large space antenna
[AIAA PAPER 87-2253] p 86 A87-50417
Active damping control design for the COFS Mast Flight System — Control of Flexible Structures program for NASA
[AIAA PAPER 87-2321] p 23 A87-50442
A laboratory simulation of flexible spacecraft control
[AIAA PAPER 87-2325] p 24 A87-50446
The mission function control for deployment and retrieval of subsatellite
[AIAA PAPER 87-2326] p 126 A87-50447
Reduced-order compensation - LQG reduction versus optimal projection
[AIAA PAPER 87-2388] p 61 A87-50472
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
Linear quadratic control system design for Space Station pointed payloads
[AIAA PAPER 87-2530] p 161 A87-50533
Model reference adaptive control for large structural systems p 63 A87-52973
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
Variable structure control system maneuvering of spacecraft p 64 N87-21989
Integrated control/structure design and robustness
p 65 N87-22060
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-1] p 65 N87-22702
Status of the Mast experiment p 30 N87-22703
Large space structures ground experiment checkout
p 30 N87-22704
Identification of large space structures: A state-of-practice report p 31 N87-22705
A general method for dynamic analysis of structures overview p 31 N87-22707
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22708
One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 9 N87-22716
Status report and preliminary results of the spacecraft control laboratory experiment p 66 N87-22717
An overview of controls research on the NASA Langley Research Center grid p 66 N87-22720
Solar array flight dynamic experiment
p 76 N87-22722
Precision pointing and control of flexible spacecraft
p 66 N87-22723
Dual keel space station control/structures interaction study p 67 N87-22737
High speed simulation of flexible multibody dynamics
p 33 N87-22738
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739
Slewing control experiment for a flexible panel
p 76 N87-22740
Minimum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741

Space station structures and dynamics test program
p 33 N87-22751
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181065] p 34 N87-23980
NASA/DOD Control/Structures Interaction Technology, 1986
[NASA-CP-2447-PT-2] p 34 N87-24495
Joint Optics Structures Experiment (JOSE)
p 34 N87-24497
Large spacecraft pointing and shape control
p 69 N87-24498
Robust control for large space antennas
p 67 N87-24499
Large space systems technology and requirements
p 3 N87-24500
Control technology overview in CSI
p 69 N87-24507
Antenna Technology Shuttle Experiment (ATSE)
p 67 N87-24508
Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25358
A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications
[NASA-CR-177447] p 130 N87-25767
Control engineering tasks in the framework of the Columbus program
[MBB-UR-E-912/86] p 158 N87-26842
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft, phase 2
[ESA-CR(P)-2361-VOL-4] p 73 N87-27709
CONTROL THEORY
Low-authority control through passive damping
[AAS PAPER 86-004] p 55 A87-32730
Modeling, stabilization and control of serially connected beams p 21 A87-41052
Robust nonlinear attitude control of flexible spacecraft
p 60 A87-48273
The mission function control for deployment and retrieval of subsatellite
[AIAA PAPER 87-2326] p 126 A87-50447
Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2387] p 24 A87-50471
Square root state estimator for large space structures
[AIAA PAPER 87-2389] p 24 A87-50473
An analytical and experimental investigation of output feedback vs. linear quadratic regulator -- for large space structures
[AIAA PAPER 87-2390] p 61 A87-50474
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371
Air Force basic research in dynamics and control of large space structures p 63 N87-20577
OPUS: Optimal Projection for Uncertain Systems
[AD-A178620] p 29 N87-21025
Modeling and control of flexible structures
[AD-A177106] p 29 N87-21388
A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731
Control of flexible structures and the research community p 66 N87-22732
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 9 N87-22735
Dual keel space station control/structures interaction study p 67 N87-22737
On the control of structures by applied thermal gradients p 33 N87-22747
Control technology overview in CSI
p 69 N87-24507
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180806] p 71 N87-25302
The effects of structural perturbations on decoupled control -- spacecraft p 35 N87-25359
Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26036
Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-179140] p 130 N87-26063
Projection filters for modal parameter estimate for flexible structures
[NASA-CR-180303] p 36 N87-26583
Theory and application of linear servo dampers for large scale space structures p 72 N87-26670
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712
CONTROLLERS
Robustness optimization of structural and controller parameters
[AIAA PAPER 87-0791] p 14 A87-33581
Control of robot manipulator compliance
p 100 A87-45797
Robust multivariable control of large space structures using positivity p 59 A87-47610
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
Active structural controllers emulating structural elements by ICUs p 27 N87-20367
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
Integrated control/structure design and robustness
p 65 N87-22060
One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715
Electrodynamic tether p 131 N87-26449
Digital control system for space structure dampers
[NASA-CR-181253] p 72 N87-27704
CONVERGENCE
Modeling and control of flexible structures
p 28 N87-20564
COOLANTS
Superfluid helium on orbit transfer (SHOOT)
p 95 N87-21151
COOLING
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702
COORDINATES
Wave-mode coordinates and scattering matrices for wave propagation
[AD-A176998] p 29 N87-21030
COPOLYMERS
Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182623] p 110 N87-27809
CORROSION PREVENTION
Oxidation protection coatings for polymers
[NASA-CASE-LEW-14072-3] p 107 N87-23736
CORROSION RESISTANCE
Structure-property relationships in polymer resistance to atomic oxygen p 106 A87-38642
COSMIC BACKGROUND EXPLORER SATELLITE
Infra-red astronomy after IRAS p 127 A87-54197
COSMIC DUST
Micrometeorite impact on solar panels -- ESA telecommunication satellites p 82 N87-26881
COSMIC RAYS
High energy gamma ray astronomy
p 129 N87-24258
COSMONAUTS
Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21096
COST ANALYSIS
Commercialisation of space - The insurance implications p 166 A87-32480
A model for the estimation of the operations and utilisation costs of an international space station
p 168 A87-42267
Satellite servicing mission preliminary cost estimation model
[NASA-CR-171978] p 136 N87-20335
Density uncertainty effect on cost of space station reboost p 170 N87-20987
The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178182] p 9 N87-21885
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583
COST EFFECTIVENESS
20 kHz Space Station power system
p 76 A87-40378
A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521
Leadership in space transportation
p 170 A87-53989
COST ESTIMATES
Concept design and cost estimation of a free-flying space platform p 148 A87-32539
Space Station EVA systems trade-off model
[SAE PAPER 860990] p 134 A87-38767
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 3: Cost estimates and work breakdown structure/dictionary, phase 1 and 2
[NASA-CR-179144] p 3 N87-26064
COSTS
High power/large area PV systems
p 80 N87-26452
COUPLED MODES
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 166 A87-25396
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181156] p 36 N87-25605
COUPLINGS
Preloaded space structural coupling joints
[NASA-CASE-LAR-13489-1] p 38 N87-27713
CRATERING
Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870
CREW WORKSTATIONS
Space Station galley design
[SAE PAPER 860932] p 116 A87-38722
A maintenance work station for Space Station
[SAE PAPER 860933] p 167 A87-38723
CREWS
A systems analysis of emergency escape and recovery systems for the US space station
[AD-A178233] p 3 N87-23660
CRUISING FLIGHT
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2566] p 136 A87-49818
Optimal nodal transfer and aeroassisted transfer by aerocruise p 139 N87-26577
CRYOGENIC COOLING
Magnetic refrigeration for space platforms
[SAE PAPER 861724] p 118 A87-32613
Microgravity fluid management requirements of advanced solar dynamic power systems
p 77 N87-21153
CRYOGENIC EQUIPMENT
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1498] p 90 A87-43027
CRYOGENIC FLUID STORAGE
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[AIAA PAPER 87-1764] p 92 A87-48572
Advanced long term cryogenic storage systems
p 94 N87-21142
Long term cryogenic storage facility systems study
p 94 N87-21143
Space station experiment definition: Long term cryogenic fluid storage p 94 N87-21144
Helium technology issues p 94 N87-21145
Overview: Fluid acquisition and transfer
p 94 N87-21146
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement
p 94 N87-21147
Numerical modelling of cryogenic propellant behavior in low-G p 95 N87-21148
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
Cryogenic Fluid Management Flight Experiment (CFMFE) p 95 N87-21150
Superfluid helium on orbit transfer (SHOOT)
p 95 N87-21151
Microgravity fluid management in two-phase thermal systems p 95 N87-21152
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[NASA-TM-89921] p 96 N87-22949
Space station experiment definition: Long-term cryogenic fluid storage
[NASA-CR-4072] p 97 N87-24841
Design and demonstrate the performance of cryogenic components representative of space vehicles: Start basket liquid acquisition device performance analysis
[NASA-CR-179138] p 97 N87-26081
CRYOGENIC FLUIDS
On-orbit cryogenic fluid management experimental data requirements using referee fluids
[AIAA PAPER 87-1559] p 90 A87-44832
Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11369-1] p 102 N87-25583
CRYOGENIC ROCKET PROPELLANTS
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1498] p 90 A87-43027
Modeling of fluid transfer in orbit
[AIAA PAPER 87-1783] p 90 A87-45190

Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[AIAA PAPER 87-1764] p 92 A87-48572
Long term cryogenic storage facility systems study p 94 N87-21143
Numerical modeling of cryogenic propellant behavior in low-G p 95 N87-21146
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[NASA-TM-89921] p 96 N87-22949

CURRENT DENSITY
Advanced fuel cell concepts for future NASA missions p 89 N87-29930

CURRENT DISTRIBUTION
Space station electrical power distribution analysis using a load flow approach p 80 N87-29689

CYLINDRICAL BODIES
Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178269] p 10 N87-24709

CYLINDRICAL SHELLS
Vibrations and structureborne noise in space station
[NASA-CR-181281] p 39 N87-29590

D

DAMAGE
Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-26952

DAMAGE ASSESSMENT
On orbit damage assessment for large space structures
[AIAA PAPER 87-0870] p 15 A87-33634
Degradation studies of SMRM teflon p 106 A87-38641
A proposal for space tether damage indication, location, and evaluation - The Repair Monkey Module p 125 A87-43354
System identification for large space structure damage assessment p 33 N87-22750
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-28582
Space station integrated wall design and penetration damage control. Task 4: impact detection/location system
[NASA-CR-179167] p 4 N87-28583
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182931] p 110 N87-29708

DAMPERS
Digital control system for space structure dampers
[NASA-CR-181253] p 72 N87-27704

DAMPING
Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22746
Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182623] p 110 N87-27809

DATA ACQUISITION
Process control and data acquisition for commercial materials processing in space
[AIAA PAPER 87-2187] p 113 A87-48583
Data capture and processing -- for Space Station
[AIAA PAPER 87-2203] p 113 A87-48588
Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-29696

DATA BASE MANAGEMENT SYSTEMS
Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-22457
Electronic control/display interface technology p 88 N87-29161
User data management p 4 N87-29163
Advanced software tools space station focused technology p 5 N87-29164
Network operating system focus technology p 117 N87-29167

DATA BASES
Computerized aerospace materials data; Proceedings of the Workshop on Computerized Property Materials and Design Data for the Aerospace Industry, El Segundo, CA, June 23-25, 1986 p 111 A87-35282
Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries p 107 A87-51772
User data management p 4 N87-29163

DATA LINKS
Antenna systems and RF coverage for the Space Station p 2 A87-45523
User interface and payload command and control p 73 N87-29162

DATA MANAGEMENT
Autonomous decentralized system concept for Space Station p 146 A87-32541
Japanese experiment module data management and communication system p 147 A87-32542
Space Station data management system architecture p 111 A87-37293
Space station data management system - A common GSE test interface for systems testing and verification p 112 A87-37294
Communication and Data Management Systems for an orbiting platform p 112 A87-40359
On board Data Management p 112 A87-40381
Data management standards for space information systems
[AIAA PAPER 87-2205] p 113 A87-48590
Evolution of data management systems from Spacelab to Columbus
[AIAA PAPER 87-2227] p 104 A87-48605
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20630
Data management panel report -- Columbus polar platforms p 114 N87-20639
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-29696
Data management system architecture options for space stations -- Columbus project
[SES/DNP/TR/002/85] p 115 N87-28585
Study of data management system architecture options for space station -- Columbus project
[MATRA-RF/176/0932-ISS-1] p 115 N87-28586
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89265] p 116 N87-29124
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89266] p 116 N87-29144
A VHSIC general purpose processor p 116 N87-29145
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155

DATA STORAGE
Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48587
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443

DATA SYSTEMS
ESA's future integrated space data system
[AIAA PAPER 87-2190] p 153 A87-48576
Data capture and processing -- for Space Station
[AIAA PAPER 87-2203] p 113 A87-48588
The Consultative Committee for Space Data Systems Standards program
[AIAA PAPER 87-2204] p 113 A87-48589
The Space Station software support environment - Not just what, but why
[AIAA PAPER 87-2206] p 114 A87-48593
Data management system architecture options for space stations -- Columbus project
[SES/DNP/TR/002/85] p 115 N87-28585
Study of data management system architecture options for space station -- Columbus project
[MATRA-RF/176/0932-ISS-1] p 115 N87-28586
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89265] p 116 N87-29124
Information network architectures p 116 N87-29149
Fiber optics wavelength division multiplexing(components) p 117 N87-29151
Fiber optic data systems p 117 N87-29152
Advanced local area network concepts p 117 N87-29153
SS focused technology: Gateways and NOS's p 117 N87-29165
KSC Space Station Operations Language (SSOL) p 139 N87-29186

DATA TRANSFER (COMPUTERS)
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443

DATA TRANSMISSION
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20630
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443
Flight array processor p 116 N87-29148
SS focused technology: Gateways and NOS's p 117 N87-29165

DEBRIS
Simulation of on-orbit satellite fragmentations p 140 N87-24515

DECISION MAKING
A multiple attribute decision analysis of manned airlock systems
[AD-A178241] p 137 N87-23862

DECOMPRESSION SICKNESS
Energy expenditure during simulated EVA workloads
[SAE PAPER 860621] p 163 A87-38713
Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation
[SAE PAPER 860627] p 163 A87-38717

DEEP SPACE
Present and future military uses of outer space: International law, politics, and the practice of states
[AD-A178722] p 170 N87-21753

DEFENSE PROGRAM
National space transportation studies
[SAE PAPER 861681] p 160 A87-32598

DEFORMATION
Model study of simplex masts -- for space applications p 144 A87-32329
Dynamic and thermal effects in very large space structures p 25 N87-20347
Dynamics of flexible structures performing large overall motions: A geometrically-nonlinear approach p 64 N87-21325
Stress and deformation analysis of lightweight composite structures -- space antennas
[MBB-UD-489/86] p 30 N87-22269
Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180391] p 70 N87-24513

DEGRADATION
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 105 A87-32080
Selected materials issues associated with Space Station p 105 A87-32081
Degradation studies of SMRM teflon p 106 A87-38641
Future trends in spacecraft design and qualification p 2 N87-20356
System identification for large space structure damage assessment p 33 N87-22750
O-atom degradation mechanisms of materials p 141 N87-26176
Radiation charging and breakdown of insulators p 143 N87-26954
Oxygen interaction with space-power materials
[NASA-CR-181395] p 132 N87-28633

DEGREES OF FREEDOM
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004616] p 101 N87-22231
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180908] p 71 N87-25352

DELAMINATING
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads
[AIAA PAPER 87-0877] p 106 A87-33636

DEMULTIPLEXING
Fiber optics wavelength division multiplexing(components) p 117 N87-29151

DEPLOYMENT
Design consideration of mechanical and deployment properties of a coilable lattice mast p 12 A87-32340
Deployment dynamics of space structures p 58 A87-40074
Computer simulation of deployment -- solar arrays p 10 N87-29002
The extendable and retractable mast as supporting tool for rigid solar arrays p 29 N87-29012
The 21st Aerospace Mechanisms Symposium
[NASA-CP-2470] p 170 N87-29858
Folding, articulated, square truss p 40 N87-29859

DERIVATION
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures
[NASA-CR-4090] p 40 N87-29896

DESIGN ANALYSIS
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 8 A87-33560

Thermal design of the ACCESS erectable space truss
p 42 A87-34459

An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38784

Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results
[AIAA PAPER 87-2157] p 160 A87-45441

Control/dynamics simulation for preliminary Space Station design
[AIAA PAPER 87-2641] p 61 A87-50486

Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154

Maintenance evaluation for space station liquid systems p 52 N87-21155

The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178182] p 9 N87-21895

Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 66 N87-22729

A systems analysis of emergency escape and recovery systems for the US space station
[AD-A178230] p 3 N87-23660

Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 78 N87-23695

Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696

Design, development and fabrication of a deployable/retractable truss beam model for large space structures application
[NASA-CR-178287] p 35 N87-25349

Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 36 N87-25808

Shape design sensitivity analysis and optimal design of structural systems
[NASA-CR-181085] p 37 N87-26370

Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424

Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-26581

DESIGN TO COST

Concept design and cost estimation of a free-flying space platform p 146 A87-32539

A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521

DESORPTION

The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181

DIAGNOSIS

Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26703

DIELECTRICS

Spacecraft dielectric material properties and spacecraft charging -- Book p 105 A87-33100

Arc propagation, emission and damage on spacecraft dielectrics p 43 N87-26952

Automatic charge control system for geosynchronous satellites p 87 N87-26960

Thick dielectric charging on high altitude spacecraft
p 87 N87-26961

DIFFUSE RADIATION

High energy gamma ray astronomy
p 129 N87-24256

DIGITAL COMPUTERS

Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89286] p 116 N87-29144

DIGITAL FILTERS

Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2387] p 24 A87-50471

DIGITAL SIMULATION

The effect of nonlinearities on flexible structures
[AD-A181735] p 39 N87-27259

DIGITAL SYSTEMS

The effect of multipath on digital communications systems: With application to space station
[AD-A178578] p 85 N87-22678

Digital control system for space structure dampers
[NASA-CR-181253] p 72 N87-27704

DIMENSIONAL ANALYSIS

The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 118 A87-33003

DIMENSIONAL STABILITY

Critical length for stable elongated orbiting structures
p 146 A87-32619

Measuring thermal expansion in large composite structures -- for spaceborne telescopes
p 20 A87-38612

Dynamic and thermal effects in very large space structures p 25 N87-20347

DIRECTIONAL CONTROL

SPOT/MEGS design and flight results obtained -- solar array drive (MEGS) p 103 N87-29009

DISCONNECT DEVICES

Preloadable vector sensitive latch
[NASA-CASE-MSC-20810-1] p 161 N87-25062

DISCRETE FUNCTIONS

Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts
p 19 A87-35327

DISPLACEMENT

Response bounds for linear underdamped systems
[ASME PAPER 87-APM-34] p 59 A87-42505

DISPLAY DEVICES

Head-ported display analysis for Space Station applications p 111 A87-31482

Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 99 A87-31493

Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A178667] p 120 N87-22762

Electronic control/display interface technology
p 88 N87-29181

DISTORTION

Hoop/column and tetrahedral truss electromagnetic tests p 67 N87-24504

DISTRIBUTED PARAMETER SYSTEMS

Control operations in advanced aerospace systems
p 54 A87-32117

Dynamical response to pulse excitations in large space structures
[AIAA PAPER 87-0710] p 15 A87-33658

Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure
[AIAA PAPER 87-0895] p 16 A87-33689

Sensitivity of distributed structures to model order in feedback control
[AIAA PAPER 87-0900] p 56 A87-33715

Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2250] p 60 A87-50414

Adaptive identification of flexible structures by lattice filters
[AIAA PAPER 87-2456] p 24 A87-50504

On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2459] p 61 A87-50505

Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50506

Practical issues in computation of optimal, distributed control of flexible structures
[AIAA PAPER 87-2481] p 25 A87-50507

Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179726] p 35 N87-24517

Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-25805

DISTRIBUTED PROCESSING

On the performance analysis of a real-time distributed computer system p 111 A87-31518

Integration of communications and tracking data processing simulation for space station
p 115 N87-25690

Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89285] p 116 N87-29124

Distributed computer taxonomy based on O/S structure p 116 N87-29127

Advanced local area network concepts
p 117 N87-29153

Testing and analysis of DOD Ada language products for NASA p 172 N87-29155

Advanced software tools space station focused technology p 5 N87-29164

DOWNLINKING

A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521

Flight array processor p 116 N87-29148

DRAG

Effects of atmosphere on slewing control of a flexible structure p 22 A87-47805

DROPS (LIQUIDS)

Liquid droplet radiator development status -- waste heat rejection devices for future space vehicles
[AIAA PAPER 87-1537] p 43 A87-43059

Liquid droplet radiator development status
[NASA-TM-89852] p 44 N87-20253

The liquid droplet radiator in space: A parametric approach
[AD-A182805] p 40 N87-25217

DURABILITY

A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet
[NASA-TM-89854] p 96 N87-22237

DWELL

On sine dwell or broadband methods for modal testing
[AIAA PAPER 87-0861] p 18 A87-33752

DYNAMIC CHARACTERISTICS

Wave-mode coordinates and scattering matrices for wave propagation
[AD-A178866] p 29 N87-21030

Dynamic finite element modeling of flexible structures
[AD-A177166] p 30 N87-22252

Solar array flight dynamic experiment
p 78 N87-22722

Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22726

An integrated, optimization-based approach to the design and control of large space structures
[AD-A179459] p 34 N87-23693

Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180606] p 71 N87-25352

DYNAMIC CONTROL

On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0867] p 16 A87-33706

Actuators for actively controlled space structures
p 59 A87-42616

Effects of atmosphere on slewing control of a flexible structure p 22 A87-47809

Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50506

A computer program for model verification of dynamic systems p 31 N87-22710

COFS 3: multibody dynamics and control technology
p 69 N87-24508

Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179726] p 35 N87-24517

Some problems in the control of large space structures
[AD-A179880] p 70 N87-25250

DYNAMIC LOADS

Box truss antenna technology status
p 67 N87-24503

Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801

DYNAMIC MODELS

Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33687

Dynamic analysis and experiment methods for a generic space station model p 22 A87-41813

Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301

Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 30 N87-22256

Large space structures testing
[NASA-TM-100306] p 35 N87-24520

Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801

Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-29004

DYNAMIC RESPONSE

Dynamical response to pulse excitations in large space structures
[AIAA PAPER 87-0710] p 15 A87-33658

Dynamic response of a viscoelastic Timoshenko beam
[AIAA PAPER 87-0890] p 16 A87-33708

Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370

Acoustic effects on the dynamic of lightweight structures p 28 N87-20372

SAFE/DAE: Modal test in space p 77 N87-20564

A computer program for model verification of dynamic systems p 31 N87-22710

Slewing control experiment for a flexible panel
p 78 N87-22740

Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-171149] p 130 N87-26083

Dynamic analysis of the flexible boom in the N-ROSS satellite
[AD-A181486] p 72 N87-26866

An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-29637

DYNAMIC STABILITY

Instability of an elastic filament in orbit around a gravitating center p 146 A87-32615

On the dynamical stability of the space 'monorail' p 146 A87-34047

The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181267] p 73 N87-27712

DYNAMIC STRUCTURAL ANALYSIS

Modal study of simplex masts — for space applications p 144 A87-32339

MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32639

A Lanczos eigenvalue method on a parallel computer — for large complex space structure free vibration analysis
[AIAA PAPER 87-0725] p 13 A87-33565

Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Parts 2A & 2B p 15 A87-33604

Dynamical response to pulse excitations in large space structures
[AIAA PAPER 87-0710] p 15 A87-33658

Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33667

High speed simulation of multi-flexible-body systems with large rotations
[AIAA PAPER 87-0930] p 57 A87-33730

Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731

Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739

Wave propagation in periodic truss structures
[AIAA PAPER 87-0944] p 18 A87-33742

On sine dwell or broadband methods for modal testing
[AIAA PAPER 87-0861] p 18 A87-33752

Localization in disordered periodic structures
[AIAA PAPER 87-0819] p 19 A87-33757

Comparison of the Craig-Bampton and residual flexibility methods of substructure representation p 19 A87-34510

Application of reanalysis techniques in dynamic analysis of spacecraft structures p 21 A87-38624

Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures p 21 A87-40075

Experiences with the Lanczos method on a parallel computer p 21 A87-41158

A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574

Dynamic analysis and experiment methods for a generic space station model p 22 A87-41613

Interdisciplinary analysis procedures in the modeling and control of large space-based structures p 22 A87-42679

Dynamics of gyroelastic spacecraft p 59 A87-47811

Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714

Dynamic and thermal effects in very large space structures p 25 N87-20347

Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 26 N87-20348

Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A175629] p 26 N87-20355

Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357

Dynamic analysis of direct television satellite TV-SAT/TDF-1 p 66 N87-20360

Structural qualification of large spacecraft p 26 N87-20361

Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363

Modal-survey testing for system identification and dynamic qualification of spacecraft structures p 27 N87-20365

Modal testing of the Olympus development model aboard solar array p 27 N87-20366

Modeling of joints for the dynamic analysis of truss structures
[NASA-TP-2661] p 28 N87-20567

Space station structures and dynamics test program
[NASA-TP-2710] p 28 N87-20568

The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Blast and Ground Shock, Shock Testing and Analysis
[AD-A175224] p 29 N87-20574

Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-20581

SAFE/DAE: Modal test in space p 77 N87-20584

The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary
[NASA-CR-178276] p 8 N87-21020

Dynamics of flexible structures performing large overall motions: A geometrically-nonlinear approach p 64 N87-21335

Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-1] p 65 N87-22702

A general method for dynamic analysis of structures overview p 31 N87-22707

Considerations in the design and development of a space station scale model p 9 N87-22711

Precision pointing and control of flexible spacecraft p 66 N87-22723

Dynamics of trusses having nonlinear joints p 32 N87-22724

Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22726

Structural dynamics system model reduction p 32 N87-22727

Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 66 N87-22729

Vibration suppression by stiffness control p 66 N87-22730

Preliminary evaluation of a reaction control system for the space station p 67 N87-22736

High speed simulation of flexible multibody dynamics p 33 N87-22738

Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741

A new approach for vibration control in large space structures p 33 N87-22743

Modeling of controlled flexible structures with impulsive loads p 33 N87-22745

Experimental characterization of deployable trusses and joints p 33 N87-22749

System identification for large space structure damage assessment p 10 N87-22750

Space station structures and dynamics test program p 33 N87-22751

Space station structural dynamics/reaction control system interaction study p 67 N87-22753

An integrated, optimization-based approach to the design and control of large space structures
[AD-A179458] p 34 N87-23693

Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178288] p 10 N87-24709

Some problems in the control of large space structures
[AD-A179989] p 70 N87-25350

Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89098] p 37 N87-29085

DYNAMIC TESTS

Space station structures and dynamics test program
[NASA-TP-2710] p 28 N87-20568

Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 36 N87-25606

DYNAMICAL SYSTEMS

Maximum likelihood identification using an array processor p 5 A87-32121

MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32639

An identification method for flexible structures
[AIAA PAPER 87-0745] p 16 A87-33669

Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33729

Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33755

Response bounds for linear underdamped systems
[ASME PAPER 87-APM-34] p 59 A87-42505

Air Force basic research in dynamics and control of large space structures p 63 N87-20577

The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement p 94 N87-21147

A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731

Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22748

E

EARTH ALBEDO

AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits p 159 N87-29968

EARTH IONOSPHERE

A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23086

EARTH MAGNETOSPHERE

The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26607

EARTH OBSERVATIONS (FROM SPACE)

A crisis in the NASA space and earth sciences programme p 112 A87-37968

Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-266] p 128 N87-20621

The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 129 N87-20622

Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 128 N87-20625

Orbit configurations — space station polar platform p 136 N87-20629

Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20630

Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects) p 129 N87-20631

Report of the atmosphere panel p 161 N87-20633

Land panel report — International Space Station p 129 N87-20634

Ocean-ice panel report — International Space Station p 136 N87-20635

Solid Earth panel report — Columbus program p 157 N87-20636

Panel report on multidisciplinary instrumentation: New possibilities — Columbus space station p 161 N87-20637

Data management panel report — Columbus polar platforms p 114 N87-20639

The orbit configuration panel report — Columbus polar platforms p 157 N87-20640

Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25356

EARTH OBSERVING SYSTEM (EOS)

Earth resources instrumentation for the Space Station Polar Platform p 126 A87-44184

Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS p 126 A87-44186

The Earth Observing System (EOS) synthetic aperture radar (SAR) p 126 A87-44187

Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-22457

Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817

EARTH ORBITAL ENVIRONMENTS

Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31661

High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 105 A87-32060

Selected materials issues associated with Space Station p 105 A87-32061

Assessment of space environment induced microdamage in toughened composite materials p 20 A87-36609

Structure-property relationships in polymer resistance to atomic oxygen p 106 A87-38642

Effect of long-term exposure to LEO space environment on spacecraft materials p 106 A87-39426

Trends in space transportation p 168 A87-41572

The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103

Orbital debris environment resulting from future activities in space p 139 A87-44362

The problem of radiation exposure in the Space Station [DGLR PAPER 86-175] p 153 A87-48157
Effects of spark plasma discharge on the performance of large antenna structures in low Earth orbit [NASA-TM-89118] p 86 N87-20229
Advanced long term cryogenic storage systems p 94 N87-21142
Long term cryogenic storage facility systems study p 94 N87-21143
A preliminary study of extended magnetic field structures in the ionosphere [NASA-CR-181084] p 140 N87-23068
Space station: A program overview p 171 N87-24495
An evaluation of candidate oxidation resistant materials for space applications in LEO [NASA-TM-100122] p 107 N87-25430
Proceedings of the NASA Workshop on Atomic Oxygen Effects -- low earth orbital environment [NASA-CR-181163] p 141 N87-26173
Review of Low Earth Orbital (LEO) flight experiments p 131 N87-26174
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements p 108 N87-26175
Mass spectrometers and atomic oxygen p 141 N87-26176
Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment p 108 N87-26177
O-atom degradation mechanisms of materials p 141 N87-26178
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-26186
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation p 131 N87-26188
Pulsed source of energetic atomic oxygen p 108 N87-26189
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets p 45 N87-26192
Chemical interactions in Low Earth Orbit (LEO) p 108 N87-26198
Ground-based studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams p 109 N87-26200
NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-26202
An evaluation of candidate oxidation resistant materials p 110 N87-26203
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-26204
Comments on the interaction of materials with atomic oxygen p 110 N87-26206
Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-26207
EARTH ORBITAL RENDEZVOUS
Rendezvous and docking tracker [AAS PAPER 86-014] p 133 A87-52755
EARTH ORBITS
Geosynchronous earth orbit base propulsion - Electric propulsion options [AIAA PAPER 87-0990] p 89 A87-39004
Optimal shuttle altitude changes using tethers [AD-A178206] p 129 N87-22758
Optimization of payload mass placement in a dual keel space station [NASA-TM-89051] p 66 N87-23687
Simulation of on-orbit satellite fragmentations p 140 N87-24515
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code [AD-A182589] p 81 N87-26186
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits p 153 N87-26868
LEO and GEO missions p 5 N87-29915
EARTH [illegible]
Earth [illegible] instrumentation for the Space Station Polar Platform p 128 A87-44184
Land panel report -- International Space Station p 128 N87-23634
EARTH SURFACE
Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4 [NASA-CR-181073] p 115 N87-24817
EARTH-MARS TRAJECTORIES
Space Station options for constructing advanced solar sails capable of multiple Mars missions [AIAA PAPER 87-1902] p 91 A87-45287
EAST GERMANY
The GDR and the Soviet space program - The optical instrument sector of the GDR contributions p 155 A87-53059
ECONOMIC ANALYSIS
The astronaut and the robot - Short- and long-term scenarios for space technology p 101 A87-52881
ECONOMIC FACTORS
Reconstituting the US space programme p 166 A87-41218
EDUCATION
Robotic telepresence p 100 A87-46704
Ideas for educational physics experiments in space p 130 N87-25033
Workshop on Workload and Training, and Examination of their Interactions: Executive summary [NASA-TM-89452] p 171 N87-25780
EFFICIENCY
20 kHz Space Station power system p 76 A87-40279
EIGENVALUES
A Lanczos eigenvalue method on a parallel computer -- for large complex space structure free vibration analysis [AIAA PAPER 87-0725] p 13 A87-33585
Experiences with the Lanczos method on a parallel computer p 21 A87-41158
Robust eigensystem assignment for flexible structures [AIAA PAPER 87-2252] p 23 A87-50418
A general method for dynamic analysis of structures overview p 31 N87-22707
EIGENVECTORS
Robust eigensystem assignment for flexible structures [AIAA PAPER 87-2252] p 23 A87-50418
ELASTIC BODIES
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32120
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32615
Optimal vibration control by the use of piezoceramic sensors and actuators [AIAA PAPER 87-0959] p 18 A87-33751
A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574
Dynamics of gyroelastic spacecraft p 59 A87-47811
ELASTIC DAMPING
New time-domain identification technique -- for vibrating structures p 56 A87-40889
ELASTIC DEFORMATION
Analytical solutions for static elastic deformations of wire ropes [AIAA PAPER 87-0720] p 8 A87-33561
Modal analyses of dynamics of a deformable multibody spacecraft - The Space Station: A continuum approach [AIAA PAPER 87-0925] p 17 A87-33727
A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574
Development of full scale deployable CFRP truss for space structure p 25 A87-51793
Dynamic finite element modeling of flexible structures [AD-A177168] p 30 N87-22252
ELASTIC SHELLS
A spline-based parameter and state estimation technique for static models of elastic surfaces [NASA-CR-180449] p 11 N87-20107
ELASTIC WAVES
An experimental study of transient waves in a plane grid structure [AIAA PAPER 87-0942] p 18 A87-33741
ELASTODYNAMICS
Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20383
Modal-survey testing for system identification and dynamic qualification of spacecraft structures p 27 N87-20385
ELASTOMERS
Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-26197
ELASTOPLASTICITY
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts [NASA-CR-180017] p 38 N87-27260
ELECTRIC ARCS
Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-26952
Automatic charge control system for geosynchronous satellites p 87 N87-26960
ELECTRIC BATTERIES
Space Electrochemical Research and Technology (SERT) [NASA-CP-2484] p 5 N87-29814
ELECTRIC CHARGE
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft [AD-A178815] p 140 N87-21024
Investigation of beam-plasma interactions [NASA-CR-180579] p 129 N87-22508
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell [NASA-TM-100102] p 79 N87-24639
Documentation for the SHADO particle wake routine [AD-A181531] p 131 N87-26887
ELECTRIC DISCHARGES
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell [NASA-TM-100102] p 79 N87-24639
Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-26952
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code [AD-A182589] p 81 N87-26186
ELECTRIC ENERGY STORAGE
Development of an alkaline fuel cell subsystem [NASA-CR-172002] p 81 N87-29158
ELECTRIC GENERATORS
The liquid droplet radiator in space: A parametric approach [AD-A182655] p 46 N87-29217
ELECTRIC MOTORS
Plasma motor/generator reference system designs for power and propulsion [AAS PAPER 86-229] p 80 A87-38572
ELECTRIC POTENTIAL
Potential modulation on the SCATHA spacecraft p 139 A87-34480
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft [AD-A178815] p 140 N87-21024
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell [NASA-TM-100102] p 79 N87-24639
ELECTRIC POWER
The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35786
ELECTRIC POWER SUPPLIES
Power management equipment for space applications [SAE PAPER 861621] p 74 A87-32578
An integrated analytic tool and knowledge-based system approach to aerospace electric power system control [SAE PAPER 861622] p 74 A87-32579
Space Station 20-kHz power management and distribution system p 75 A87-36213
Space station electric power system requirements and design [NASA-TM-89588] p 96 N87-22301
ELECTRIC POWER TRANSMISSION
Space station electrical power distribution analysis using a load flow approach p 80 N87-29888
ELECTRIC PROPULSION
Electric propulsion for orbit transfer - A NAVSTAR case study (Has electric propulsion's time come?) [AIAA PAPER 87-0985] p 88 A87-38001
The use of electric propulsion on low earth orbit spacecraft [AIAA PAPER 87-0989] p 88 A87-38003
Geosynchronous earth orbit base propulsion - Electric propulsion options [AIAA PAPER 87-0990] p 89 A87-39004
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU) [AIAA PAPER 87-1040] p 76 A87-39828
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU) [AIAA PAPER 87-1041] p 76 A87-39829
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40510
1987 status report - United States Air Force electric propulsion research and development [AIAA PAPER 87-1036] p 90 A87-41132
Advanced propulsion activities in the USA p 90 A87-41575
ELECTRIC WIRE
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40510
ELECTRICAL FAULTS
Thermal deformation and electrical degradation of antenna reflector with truss backstructure p 12 A87-32405
Thick dielectric charging on high altitude spacecraft p 87 N87-26961
ELECTRICAL IMPEDANCE
Frequency dispersion in the admittance of the polycrystalline CuInSe2/CdS solar cell p 5 A87-29

ELECTRICAL INSULATION
MARECS and ECS anomalies: Attempts at insulation defect production in Kapton p 82 N87-28080
ELECTRO-OPTICS
The Radiant Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25008
ELECTROCATALYSTS
Space Electrochemical Research and Technology (SERT)
[NASA-CP-2484] p 5 N87-29914
ELECTROCHEMISTRY
Space Electrochemical Research and Technology (SERT)
[NASA-CP-2484] p 5 N87-29914
ELECTRODYNAMICS
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-210] p 89 A87-38580
Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40510
Theory of plasma contactors for electrodynamic tethered satellite systems p 85 A87-41809
The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42585
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180822] p 129 N87-22509
Thermal and dynamical effects on electrodynamic space tethers
[AD-A180276] p 130 N87-25351
Electrodynamic tether p 131 N87-26449
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 121 N87-29591
Oxygen interaction with space-power materials
[NASA-CR-181386] p 102 N87-29603
ELECTROLUMINESCENCE
Head-ported display analyses for Space Station applications p 111 A87-31463
ELECTROLYSIS
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712
Space Station life support oxygen generation by SPE water electrolyzer systems
[SAE PAPER 860949] p 49 A87-38736
Electrochemical processing of solid waste
[NASA-CR-181128] p 127 N87-25443
Hydrogen/oxygen economy for the space station p 98 N87-26130
ELECTROMAGNETIC INTERFERENCE
Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit
[NASA-TM-89118] p 98 N87-20339
EMC and power quality standards for 20-kHz power distribution
[NASA-TM-89825] p 79 N87-22004
ELECTROMAGNETIC PROPERTIES
Measurement apparatus and procedure for the determination of surface emissivities
[NASA-CASE-LAR-13455-1] p 29 N87-21208
Documentation for the SHADO particle wake routine
[AD-A181531] p 131 N87-26087
ELECTROMAGNETIC RADIATION
Hoop/column and tetrahedral truss electromagnetic tests p 67 N87-24504
ELECTROMAGNETISM
Controls-structures-electromagnetics interaction program p 69 N87-24502
ELECTROMECHANICAL DEVICES
An electromechanical attenuator/actuator for Space Station docking p 139 N87-29879
ELECTRON BEAMS
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
ELECTRON BOMBARDMENT
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit p 158 N87-29853
ELECTRON GUNS
Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22508
Electron beam experiments at high altitudes p 142 N87-29848
ELECTRON IRRADIATION
Assessment of space environment induced microdamage in toughened composite materials p 20 A87-38405
Surface modification to minimize the electrostatic charging of Kapton in the space environment p 87 N87-29859
ELECTRON TRANSITIONS
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181
ELECTRONIC CONTROL
Electronic control/display interface technology p 99 N87-29181
ELECTROSTATIC CHARGE
Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22508
Electrostatic immunity of geostationary satellites p 143 N87-29857
Surface modification to minimize the electrostatic charging of Kapton in the space environment p 87 N87-29859
Automatic charge control system for geosynchronous satellites p 87 N87-29860
Stopping differential charging of solar arrays p 83 N87-29864
ELECTROSTATICS
Electron beam experiments at high altitudes p 142 N87-29848
ELECTROTHERMAL ENGINES
Performance of an SP-100/pulsed electrothermal thruster orbit transfer vehicle
[AIAA PAPER 87-2027] p 77 A87-45383
ELEVATORS (LIFTS)
Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-179149] p 130 N87-26083
EMBEDDED COMPUTER SYSTEMS
A VHSIC general purpose processor p 116 N87-29145
MAX: A space station computer option p 116 N87-29146
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155
EMERGENCIES
A systems analysis of emergency escape and recovery systems for the US space station
[AD-A179230] p 3 N87-23680
ENCLOSURES
An evaluation of advanced extravehicular crew enclosures
[SAE PAPER 861009] p 134 A87-38781
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-38782
END EFFECTORS
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547
Space Station end effector strategy study
[NASA-TM-100488] p 103 N87-29583
END-TO-END DATA SYSTEMS
End-to-end communications for Space Station p 85 A87-45522
ENERGETIC PARTICLES
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181
ENERGY CONSERVATION
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs
[SAE PAPER 860987] p 51 A87-38768
ENERGY CONSUMPTION
Energy expenditure during simulated EVA workloads
[SAE PAPER 860921] p 183 A87-38713
ENERGY CONVERSION EFFICIENCY
Advanced photovoltaic solar array design assessment p 80 N87-29429
ENERGY DISSIPATION
Global treatment of energy dissipation effects for multibody satellites p 62 A87-51810
ENERGY DISTRIBUTION
Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-39624
System identification for large space structure damage assessment p 50 N87-22750
ENERGY METHODS
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLPF method p 144 A87-32334
ENERGY STORAGE
Intelligent flywheel energy storage units with additional functions for future space stations in near-earth orbits
[DGLR PAPER 86-173] p 77 A87-36762
A transient analysis of phase change energy storage system for solar dynamic power
[AIAA PAPER 87-1482] p 77 A87-43004
Application of advanced flywheel technology for energy storage on space station
[DE87-007657] p 96 N87-24025
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell
[NASA-TM-100102] p 79 N87-24836
JPL future missions and energy storage technology implications p 84 N87-29617
Advanced fuel cell concepts for future NASA missions p 89 N87-29630
Application of advanced flywheel technology for energy storage on space station p 74 N87-29650
Regenerative fuel cells for space applications p 84 N87-29636
ENERGY TECHNOLOGY
Advanced technology for extended endurance alkaline fuel cells p 75 A87-33797
RI department head on orbital power plants p 1C N87-27683
ENERGY TRANSFER
RI department head on orbital power plants p 158 N87-27683
ENGINE DESIGN
Concepts for space maintenance of OTV engines p 137 N87-29097
ENGINE MONITORING INSTRUMENTS
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-39829
ENGINE TESTING LABORATORIES
Space station propulsion test bed: A complete system p 98 N87-26131
ENGINE TESTS
Ion thrusters advance p 83 A87-54198
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 98 N87-26133
ENGINEERING MANAGEMENT
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 83 A87-50167
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 86 N87-23621
ENVIRONMENT POLLUTION
Resistojet plume and induced environment analysis
[NASA-TM-89857] p 86 N87-24328
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4081] p 51 N87-29098
ENVIRONMENT SIMULATION
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181309] p 45 N87-29072
ENVIRONMENTAL CONTROL
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station p 46 A87-32544
Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986
[SAE P-177] p 182 A87-38701
EDC development and testing for the Space Station program — Electrochemical Carbon Dioxide Concentration
[SAE PAPER 860918] p 118 A87-38710
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-38729
Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 43 A87-38730
Environmental Control Life Support for the Space Station
[SAE PAPER 860944] p 48 A87-38731
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements
[SAE PAPER 860945] p 48 A87-38732
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 49 A87-38733
Evaluation of regenerative portable life support system options
[SAE PAPER 860948] p 49 A87-38735
Physiological requirements and pressure control of a spacestation
[SAE PAPER 860985] p 150 A87-38747
Columbus Life Support System and its technology development
[SAE PAPER 860986] p 150 A87-38748
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860994] p 51 A87-38771
CELSS waste management systems evaluation
[SAE PAPER 860997] p 51 A87-38774
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 861007] p 52 A87-38779

ENVIRONMENTAL MONITORING

Vapor fragrancer
[NASA-CASE-LAR-13660-1] p 165 N87-25561

ENVIRONMENTAL TESTS

Proceedings of the NASA Workshop on Atomic Oxygen Effects — low earth orbital environment
[NASA-CR-181163] p 141 N87-26173

An evaluation of candidate oxidation resistant materials p 110 N87-26203

Comments on the interaction of materials with atomic oxygen p 110 N87-26206

ENVIRONMENTS

SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

EPOXY RESINS

Dynamic analysis of the flexible boom in the N-ROSS satellite
[AD-A181488] p 72 N87-26966

EQUATIONS OF MOTION

Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-40867

Effect of crew motions on the spatial position of a spacecraft p 152 A87-41954

Equations of motion for maneuvering flexible spacecraft p 63 A87-52985

Equations of motion of a space station with emphasis on the effects of the gravity gradient
[NASA-TM-86588] p 64 N87-21993

Structural dynamics system model reduction p 32 N87-22727

Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22746

Optimal shuttle altitude changes using tethers
[AD-A179205] p 129 N87-22756

EQUIPMENT SPECIFICATIONS

A space debris simulation facility for spacecraft materials evaluation p 11 A87-32058

Vibration isolation for line of sight performance improvement p 67 N87-22742

EROSION

The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181

Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-26207

Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182931] p 110 N87-29709

ESA SPACECRAFT

Modal-survey testing of the Olympus spacecraft p 152 A87-42288

ESCAPE SYSTEMS

A systems analysis of emergency escape and recovery systems for the US space station
[AD-A178233] p 3 N87-23880

ESTIMATES

Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183302] p 11 N87-29863

ETCHING

Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-26197

EULER EQUATIONS OF MOTION

Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26038

EURECA (ESA)

Eureca - A first step towards the Space Station p 146 A87-32537

Status of the RITA - Experiment on EURECA — Radio Frequency Ion Thruster Assembly
[AIAA PAPER 87-0989] p 123 A87-36002

The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860938] p 42 A87-38725

Microgravity experiments onboard Eureca p 155 A87-53564

From Eureca-A to Eureca-B p 155 A87-53916

Botanical payloads for platforms and space stations
[MBB-UR-E-921/86] p 159 N87-25340

The evolution of a serviceable EURECA
[MBB-UR-E-923/86] p 121 N87-26841

EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 82 N87-26973

Improved solar generator technology for the EURECA low Earth orbit p 159 N87-26974

Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration p 83 N87-26985

EUROPEAN SPACE AGENCY

The Space Station overview p 169 A87-41571

ESA's future integrated space data system
[AIAA PAPER 87-2180] p 153 A87-48578

ESA software engineering standards for future programmes
[AIAA PAPER 87-2207] p 154 A87-48592

Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-48595

The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 128 N87-20622

Possibilities of the further development of Columbus to an autonomous European space station
[MBB-UR-E-922/86] p 158 N87-25418

Space 2000 in Europe p 159 N87-29024

EUROPEAN SPACE PROGRAMS

Europe's future in space p 143 A87-32279

Highlights of the German Space Programme p 143 A87-32282

Space Station - Overview of the European concept of Columbus programme status and content p 145 A87-32528

Design of a polar platform with an earth observation payload p 122 A87-32538

International cooperation in space p 149 A87-34584

The European space programme p 150 A87-37962

System aspects of Columbus thermal control
[SAE PAPER 860938] p 150 A87-38727

Europe prepares for manned orbited operations p 151 A87-39594

The Space Station - Uses and users p 151 A87-40513

Thoughts on Europe's future in space p 151 A87-41219

Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-182] p 80 A87-42880

The Columbus system baseline and interfaces p 156 A87-53823

Cooperation between Europe and the United States in space (The Fulbright 40th Anniversary Lecture) p 170 A87-53824

The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 128 N87-20622

The Columbus program: An overview p 156 N87-20623

European utilization aspects studies — space stations p 156 N87-20624

ESA Columbus polar platform design concept p 156 N87-20627

Servicing of the polar platform — Columbus space station p 136 N87-20629

USA-Europe coordination and cooperation activities: Announcements of Opportunity — polar platforms p 170 N87-20632

The Columbus program p 157 N87-25031

Study of expert system applications to space projects
[NE-61-887] p 115 N87-26057

Control engineering tasks in the framework of the Columbus program
[MBB-UH-E-912/86] p 158 N87-26842

Data management system architecture options for space stations — Columbus project
[SES/DNP/TR/002/86] p 115 N87-29585

Study of data management system architecture options for space station — Columbus project
[MATRA-RF/176/0832-ISS-1] p 115 N87-29586

Space 2000 in Europe p 159 N87-29024

EVALUATION

Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735

An evaluation of candidate oxidation resistant materials for space applications in LEO
[NASA-TM-100122] p 107 N87-29480

Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89088] p 37 N87-29085

EVAPORATION

Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860979] p 42 A87-38760

Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26180

EVAPORATORS

High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-32377

Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32380

EXHAUST GASES

Hydrogen-oxygen thruster with no products of combustion in exhaust plume
[AIAA PAPER 87-1775] p 91 A87-45180

Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 92 A87-52252

EXOBIOLOGY

Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-38740

Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002

Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732

Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2336] p 158 N87-27686

EXPANDABLE STRUCTURES

Deployable geodesic truss structure
[NASA-CASE-LAR-13113-1] p 36 N87-25492

EXPENDABLE STAGES (SPACECRAFT)

Liquid propulsion technology for expendable and STS launch vehicle transfer stages
[AIAA PAPER 87-1934] p 92 A87-45311

EXPERIMENT DESIGN

System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0745] p 16 A87-33670

Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34208

Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1858] p 91 A87-45256

Cryogenic Fluid Management Flight Experiment (CFMFE) p 95 N87-21150

Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21158

Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary — laboratory test model
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707

Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report — laboratory test model
[ESA-CR(P)-2381-VOL-2] p 73 N87-27708

Optimizing experimental programs in operational planning of research carried out from spacecraft p 160 N87-29553

EXPERT SYSTEMS

Expert systems in space p 111 A87-32075

An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579

User interface design guidelines for expert troubleshooting systems — for Space Station p 6 A87-33050

Complex system monitoring and fault diagnosis using communicating expert systems p 119 A87-40093

Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48802

The Oak Ridge National Laboratory's Robotics and Intelligent Systems Program
[DE87-004627] p 101 N87-20774

Study of expert system applications to space projects
[NE-61-887] p 115 N87-26057

Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89095] p 116 N87-29124

Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89096] p 116 N87-29144

EXPOSURE

Review of Low Earth Orbital (LEO) flight experiments p 131 N87-29174

Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements p 108 N87-29175

Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment p 108 N87-29177

O-atom degradation mechanisms of materials p 141 N87-29179

EXTENSIONS

Evaluation of carbon-carbon for space engine nozzle p 99 N87-29116

EXTRASOLAR PLANETS

Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

Astrometric Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description
[NASA-TM-89429-VOL-2] p 129 N87-22570

Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary
[NASA-TM-89429-VOL-1] p 129 N87-22571

EXTRATERRESTRIAL ENVIRONMENTS
Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-38643
EXTRATERRESTRIAL RADIATION
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-49026
EXTRAVEHICULAR ACTIVITY
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31462
Space Station EVA simulation demonstrates orbital assembly p 132 A87-32008
Computer simulation of on-orbit manned maneuvering unit operations
[SAE PAPER 861783] p 47 A87-32632
Energy expenditure during simulated EVA workloads
[SAE PAPER 860921] p 163 A87-38713
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734
Evaluation of regenerative portable life support system options
[SAE PAPER 860948] p 49 A87-38735
Desirability of arms-in capability in space suits
[SAE PAPER 860951] p 49 A87-38738
The development of an EVA Universal Work Station
[SAE PAPER 860952] p 164 A87-38739
Space Station EVA systems trade-off model
[SAE PAPER 860980] p 134 A87-38767
Physiological aspects of EVA
[SAE PAPER 860981] p 164 A87-38768
Advanced orbital servicing capabilities development
[SAE PAPER 860982] p 134 A87-38769
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
An evaluation of advanced extravehicular crew enclosures
[SAE PAPER 861009] p 134 A87-38781
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-38782
The next step for the MMU - Capabilities and enhancements
[SAE PAPER 861013] p 160 A87-38783
On-board communications, including EVA
p 85 A87-40380
Dynamic behavior of astronauts and satellites outside an orbiting space station under the influence of thrust
p 52 A87-41666
Advanced EVA system design requirements study: EVAS/space station system interface requirements
[NASA-CR-171981] p 120 N87-20351
A multiple attribute decision analysis of manned airlock systems
[AD-A178241] p 137 N87-23882
Human factors in space station architecture 2. EVA access facility: A comparative analysis of 4 concepts for on-orbit space suit servicing
[NASA-TM-86856] p 52 N87-24084
Space suit extravehicular hazards protection development
[NASA-TM-88358] p 53 N87-27407
EXTRAVEHICULAR MOBILITY UNITS
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734
Evaluation of regenerative portable life support system options
[SAE PAPER 860948] p 49 A87-38735
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-38782
EXTREMELY HIGH FREQUENCIES
On-board K- and S-band multi-beam antennas
p 88 A87-48281

F

FACTORIZATION
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179728] p 35 N87-24517
FAILURE ANALYSIS
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-28889
FAILURE MODES
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37053
FAINT OBJECT CAMERA
Qualification of the faint object camera
p 127 N87-20889
FAST FOURIER TRANSFORMATIONS
A modern approach for modal testing using multiple input sine excitation
[AIAA PAPER 87-0984] p 19 A87-33754
FASTENERS
Joint technology for graphite epoxy space structures
p 20 A87-38600
FATIGUE (MATERIALS)
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20589
FATIGUE LIFE
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20589
FAULT TOLERANCE
Autonomous decentralized system concept for Space Station p 146 A87-32541
Space station electric power system requirements and design
[NASA-TM-89886] p 96 N87-22001
MAX: A space station computer option
p 116 N87-29146
FEASIBILITY ANALYSIS
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel
p 113 A87-45485
FECES
Electrochemical processing of solid waste
[NASA-CR-181129] p 137 N87-25443
FEDERAL BUDGETS
Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-73-418] p 171 N87-22580
National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240
National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-25024
National Aeronautics and Space Administration
p 172 N87-30220
NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988
[GPO-73-245] p 172 N87-30221
FEEDBACK CONTROL
Vibration suppression using a constrained rate-feedback Threshold control strategy — for large space structures
[AIAA PAPER 87-0741] p 6 A87-33686
Sensitivity of distributed structures to model order in feedback control
[AIAA PAPER 87-0800] p 56 A87-33710
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
Adaptive tracking of dynamical model by uncertain nonlinearizable spacecraft
[AIAA PAPER 87-0940] p 57 A87-33738
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0959] p 18 A87-33751
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-38729
Control of robot manipulator compliance
p 100 A87-45787
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-45790
Robust multivariable control of large space structures using positivity p 59 A87-47810
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50033
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2249] p 60 A87-50413
Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2250] p 60 A87-50414
Robust eigensystem assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416
Robust control of a large space antenna
[AIAA PAPER 87-2253] p 90 A87-50417
Suboptimal feedback vibration control of a beam with a proof-mass actuator — large space structures
[AIAA PAPER 87-2323] p 23 A87-50444
An analytical and experimental investigation of output feedback vs. linear quadratic regulator — for large space structures
[AIAA PAPER 87-2390] p 61 A87-50474
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2484] p 93 A87-50509
Modeling and control of flexible structures
p 28 N87-20584
Integrated control/structure design and robustness
p 65 N87-22080
Large space structures ground experiment checkout
p 30 N87-22704
One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715
Flexible spacecraft simulator p 31 N87-22718
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
Control of flexible structures and the research community p 66 N87-22732
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734
Robust control for large space antennas
p 67 N87-24489
Large space structures testing
[NASA-TM-100308] p 35 N87-24520
Some problems in the control of large space structures
[AD-A179889] p 70 N87-25350
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-25805
FIBER COMPOSITES
Fiber composites in satellites
[MBB-UD-492/86] p 107 N87-25430
FIBER OPTICS
Fiber-optic monitors for space structures
p 11 A87-31505
Star topology spacecraft data bus
p 112 A87-37431
Proof that timing requirements of the FDDI token ring protocol are satisfied — fiber distributed data interface
p 112 A87-42821
Information network architectures p 116 N87-29149
Fiber optics wavelength division multiplexing(components) p 117 N87-29151
Fiber optic data systems p 117 N87-29152
Advanced local area network concepts
p 117 N87-29153
Fiber optics common transceiver module
p 117 N87-29160
SS focused technology: Gateways and NOS's
p 117 N87-29165
Network operating system p 117 N87-29166
FIBER ORIENTATION
Development of graphite epoxy space structure
p 105 A87-32342
FINANCE
National Aeronautics and Space Administration
p 172 N87-30220
FINITE ELEMENT METHOD
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLFF method
p 144 A87-32334
A modern approach for modal testing using multiple input sine excitation
[AIAA PAPER 87-0984] p 19 A87-33754
A hybrid nonlinear programming method for design optimization p 7 A87-35719
Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714
Model reference adaptive control for large structural systems p 63 A87-52873
Modal-survey testing for system identification and dynamic qualification of spacecraft structures
p 27 N87-20386
Modeling and control of flexible structures
p 28 N87-20584
OPUS: Optimal Projection for Uncertain Systems
[AD-A178820] p 29 N87-21025
Dynamic finite element modeling of flexible structures
[AD-A177168] p 30 N87-22252
A general method for dynamic analysis of structures overview p 31 N87-22707
Equivalent beam modeling using numerical reduction techniques p 32 N87-22726
Structural dynamics system model reduction
p 32 N87-22727
Dual keel space station control/structures interaction study p 67 N87-22737
Application of physical parameter identification to finite-element models p 34 N87-24606

Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180391] p 70 N87-24513
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-25805
FIRE PREVENTION
Fire safety concerns in space operations
[NASA-TM-89848] p 165 N87-20342
FLEXIBILITY
Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714
FLEXIBLE BODIES
Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32857
Static shape control for flexible structures
[SAE PAPER 861822] p 13 A87-32858
An identification method for flexible structures
[AIAA PAPER 87-0745] p 16 A87-33669
Sensitivity of distributed structures to model order in feedback control
[AIAA PAPER 87-0900] p 56 A87-33710
Gradient-based combined structural and control optimization p 21 A87-40886
Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-40887
Modeling, stabilization and control of serially connected beams p 21 A87-41052
On the inadequacies of current multi-flexible body simulation codes
[AIAA PAPER 87-2248] p 7 A87-50412
Robust eigensystem assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416
Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2387] p 24 A87-50471
Adaptive identification of flexible structures by lattice filters
[AIAA PAPER 87-2458] p 24 A87-50504
Dynamic and thermal effects in very large space structures p 25 N87-20347
Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 26 N87-20348
Modeling and control of flexible structures
p 28 N87-20594
Air Force basic research in dynamics and control of large space structures p 63 N87-20577
Modeling and control of flexible structures
[AD-A177108] p 29 N87-21388
Integrated control/structure design and robustness
p 6 N87-22080
Dynamic finite element modeling of flexible structures
[AD-A177169] p 30 N87-22252
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-1] p 65 N87-22702
Status of the Mast experiment p 30 N87-22703
Microprocessor controlled proof-mass actuator
p 65 N87-22708
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22709
Considerations in the design and development of a space station scale model p 9 N87-22711
Verification of large beam-type space structures
p 31 N87-22712
Verification of flexible structures by ground test
p 31 N87-22713
Status report and preliminary results of the spacecraft control laboratory experiment p 66 N87-22717
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 66 N87-22729
Vibration suppression by stiffness control
p 66 N87-22730
Control of flexible structures and the research community p 66 N87-22732
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 9 N87-22735
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739
Slewing control experiment for a flexible panel
p 76 N87-22740
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
An integrated, optimization-based approach to the design and control of large space structures
[AD-A179400] p 34 N87-23083
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181088] p 34 N87-23850
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179728] p 35 N87-24817
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181156] p 36 N87-25805
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-25805
Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-26367
Projection filters for modal parameter estimate for flexible structures
[NASA-CR-180303] p 38 N87-26583
An investigation of methodology for the control and failure identification of flexible structures
p 38 N87-26621
Dynamic analysis of the flexible boom in the N-ROSS satellite
[AD-A181468] p 72 N87-26968
Computer simulation of a rotational single-element flexible spacecraft boom
[AD-A181798] p 103 N87-26969
The effect of nonlinearities on flexible structures
[AD-A181735] p 38 N87-27259
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183302] p 11 N87-29893
FLEXIBLE SPACECRAFT
Robust controller design using frequency domain constraints p 11 A87-32229
Robust controller synthesis for a large flexible space antenna p 84 A87-32235
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236
A review of modelling techniques for the open and closed-loop dynamics of large space systems
p 12 A87-32337
Transient dynamics of orbiting flexible structural members p 54 A87-32338
A consideration to vibration control for a large space structures p 54 A87-32441
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Vibration control for a [illegible] system of flexible structures p 55 A87-32444
Precise pointing control of flexible spacecraft
p 55 A87-32446
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel
p 55 A87-32448
Control of a flexible space manipulator
p 89 A87-32449
An assessment of recent advances in modeling and control design of space structures under uncertainty
[SAE PAPER 861816] p 147 A87-32855
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32729
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32915
Critical length for stable elongated orbiting structures
p 148 A87-32919
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 58 A87-33573
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33610
Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0829] p 14 A87-33613
Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33687
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure
[AIAA PAPER 87-0885] p 16 A87-33699
On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0887] p 16 A87-33700
Dynamic response of a viscoelastic Timoshenko beam
[AIAA PAPER 87-0890] p 16 A87-33703
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33705
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0908] p 17 A87-33712
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
Modal analyses of dynamics of a deformable multibody spacecraft - The Space Station: A continuum approach
[AIAA PAPER 87-0925] p 17 A87-33727
High speed simulation of multi-flexible-body systems with large rotations
[AIAA PAPER 87-0930] p 57 A87-33730
Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737
Adaptive tracking of dynamical model by uncertain nonlinearizable spacecraft
[AIAA PAPER 87-0940] p 57 A87-33738
An experimental study of transient waves in a plane grid structure
[AIAA PAPER 87-0943] p 18 A87-33741
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0901] p 19 A87-34701
Control of flexible structures by applied thermal gradients p 21 A87-39543
Deployment dynamics of space structures
p 58 A87-40074
A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
Interdisciplinary analysis procedures in the modeling and control of large space-based structures
p 22 A87-42878
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46780
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47909
Dynamics of gyroelastic spacecraft p 59 A87-47911
Robust nonlinear attitude control of flexible spacecraft
p 60 A87-48273
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50035
Construction of positive real compensation for LSS control — applied to Large Space Structure model
[AIAA PAPER 87-2239] p 60 A87-50404
Active damping control design for the COFS Mast Flight System — Control of Flexible Structures program for NASA
[AIAA PAPER 87-2321] p 23 A87-50442
Active vibration control synthesis for the COFS-I - A classical approach — Control of Flexible Structures experiment for NASA
[AIAA PAPER 87-2322] p 23 A87-50443
Suboptimal feedback vibration control of a beam with a proof-mass actuator — large space structures
[AIAA PAPER 87-2323] p 23 A87-50444
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445
A laboratory simulation of flexible spacecraft control
[AIAA PAPER 87-2325] p 24 A87-50446
Practical issues in computation of optimal, distributed control of flexible structures
[AIAA PAPER 87-2481] p 25 A87-50507
Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2589] p 62 A87-50581
Equations of motion for maneuvering flexible spacecraft p 63 A87-52956
Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A178829] p 26 N87-20055
Future trends in spacecraft design and qualification
p 2 N87-20056
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 106 N87-20057
Dynamic modeling and optimal control design for large flexible space structures p 26 N87-20060
Structural qualification of large spacecraft
p 26 N87-20061
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20069
OPUS: Optimal Projection for Uncertain Systems
[AD-A178859] p 29 N87-21025
Dynamics of flexible structures performing large overall motions: A geometrically-nonlinear approach
p 64 N87-21326
Variable structure control system maneuvering of spacecraft p 64 N87-21569
Flexible spacecraft simulator p 31 N87-22716
An overview of controls research on the NASA Langley Research Center grid p 65 N87-22720
Precision pointing and control of flexible spacecraft
p 66 N87-22723
Large spacecraft pointing and shape control
p 69 N87-24408

COFS 3 multibody dynamics and control technology p 69 N87-24506
Ground test of large flexible structures p 34 N87-24510
Slew maneuvers on the SCOLE Laboratory Facility p 69 N87-24511
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities [AD-A180606] p 71 N87-25352
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25355
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25356
A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 35 N87-25357
Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25358
Active vibration damping of flexible structures using the traveling wave approach p 71 N87-25360
Maximum likelihood parameter identification of flexible spacecraft [ETN-87-90235] p 36 N87-27705
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report [ESA-CR(P)-2381-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary — laboratory test model [ESA-CR(P)-2381-VOL-1] p 73 N87-27707
Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report — laboratory test model [ESA-CR(P)-2381-VOL-2] p 73 N87-27708
Study on investigation of the attitude control of large flexible spacecraft, phase 3 [ESA-CR(P)-2381-VOL-4] p 73 N87-27709

FLEXING
Effect of bonding on the performance of a piezoactuator-based active control system [NASA-CR-181414] p 74 N87-29713
Optimum shape control of flexible beams by piezo-electric actuators [NASA-CR-181413] p 40 N87-29866

FLIGHT CHARACTERISTICS
Modeling of environmentally induced transients within satellites [AIAA PAPER 85-0387] p 7 A87-41811

FLIGHT CONTROL
System level verification applying the Space Shuttle experience to the Space Station [AAS PAPER 86-001] p 55 A87-32727
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295
Japanese space information system overview [AIAA PAPER 87-2181] p 153 A87-48579
OPUS: Optimal Projection for Uncertain Systems [AD-A178820] p 29 N87-21025

FLIGHT LOAD RECORDERS
Analysis of Intelsat V flight data [AIAA PAPER 87-0784] p 16 A87-33879

FLIGHT MECHANICS
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results [NASA-CR-179141] p 4 N87-26066

FLIGHT OPERATIONS
Design and development of a Space Station proximity operations research and development mockup [SAE PAPER 861786] p 133 A87-32834

FLIGHT PATHS
Singular perturbation analysis of AOTV related trajectory optimization problems [NASA-CR-180201] p 137 N87-26027

FLIGHT SIMULATORS
A simulation capability for future space flight [SAE PAPER 861784] p 69 A87-32832
Documentation of the space station/aircraft acoustic apparatus [NASA-TM-89111] p 140 N87-20786

FLIGHT TESTS
Laser docking system flight experiment [AAS PAPER 86-043] p 59 A87-32748
The Tethered Satellite System as a new remote sensing platform p 124 A87-39103
Liquid droplet radiator development status — waste heat rejection devices for future space vehicles [AIAA PAPER 87-1537] p 43 A87-43058
Liquid droplet radiator development status [NASA-TM-89852] p 44 N87-20883
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20870
SAFE/DAE: Modal test in space p 77 N87-20884
Solar array flight dynamic experiment p 76 N87-22722
Antenna Technology Shuttle Experiment (ATSE) p 67 N87-24508
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code [AD-A182589] p 81 N87-29186
Test results from the solar array flight experiment p 83 N87-29010

FLIGHT TRAINING
Soviet space stations as analogs, second edition [NASA-CR-180920] p 157 N87-21996

FLOW DISTRIBUTION
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-39836
Space station electrical power distribution analysis using a load flow approach p 80 N87-29899

FLUID DYNAMICS
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-39836

FLUID FLOW
Liquid sheet radiator [AIAA PAPER 87-1525] p 43 A87-43048
Analytical and experimental modeling of zero/low gravity fluid behavior [AIAA PAPER 87-1865] p 91 A87-45280

FLUID MANAGEMENT
A thermally-pumped heat transport system p 40 A87-32389
On-orbit fluid management p 132 A87-32543
Refueling satellites in space - The OSCRS program [SAE PAPER 861797] p 88 A87-32845
Maintenance components for Space Station long life fluid systems [SAE PAPER 861005] p 89 A87-36778
Space station active thermal control system modeling [AIAA PAPER 87-1466] p 43 A87-43003
Development of a prototype two-phase thermal bus system for Space Station [AIAA PAPER 87-1628] p 44 A87-43128
On-orbit cryogenic fluid management experimental data requirements using referee fluids [AIAA PAPER 87-1508] p 90 A87-44832
Space-based OTV boiloff disposition [AIAA PAPER 87-1767] p 91 A87-45191
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [AIAA PAPER 87-1764] p 92 A87-48572
Microgravity Fluid Management Symposium [NASA-CP-2465] p 94 N87-21141
Advanced long term cryogenic storage systems p 94 N87-21142
Long term cryogenic storage facility systems study p 94 N87-21143
Space station experiment definition: Long term cryogenic fluid storage p 94 N87-21144
Helium technology issues p 94 N87-21145
Overview: Fluid acquisition and transfer p 94 N87-21146
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement p 94 N87-21147
Numerical modelling of cryogenic propellant behavior in low-G p 95 N87-21148
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
Cryogenic Fluid Management Flight Experiment (CFMFE) p 95 N87-21150
Superfluid helium on orbit transfer (SHOOT) p 95 N87-21151
Microgravity fluid management in two-phase thermal systems p 95 N87-21152
Microgravity fluid management requirements of advanced solar dynamic power systems p 77 N87-21153
Maintenance evaluation for space station liquid systems p 52 N87-21156
Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21159
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [NASA-TM-88921] p 96 N87-22940
Space station experiment definition: Long-term cryogenic fluid storage [NASA-CR-4072] p 97 N87-24841

FLUID MECHANICS
Symposium on Microgravity Fluid Mechanics, Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 p 89 A87-38795
U.S. National Congress of Applied Mechanics, 10th, University of Texas, Austin, June 16-20, 1986, Proceedings [AD-A181602] p 1 A87-40801
Modeling of fluid transfer in orbit [AIAA PAPER 87-1763] p 90 A87-45190

FLUID PRESSURE
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger [AIAA PAPER 87-1540] p 44 A87-44843

FLYWHEELS
Intelligent flywheel energy storage units with additional functions for future space stations in near-earth orbits [DGLR PAPER 86-172] p 57 A87-36762
Application of advanced flywheel technology for energy storage on space station [DE87-007657] p 66 N87-24028
Application of advanced flywheel technology for energy storage on space station p 74 N87-29933

FOLDING STRUCTURES
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341
Acoustic effects on the dynamic of lightweight structures p 28 N87-20372
Development of precision structural joints for large space structures p 25 N87-20374
Deployable geodesic truss structure [NASA-CASE-LAR-13113-1] p 36 N87-25482
The high performance solar array GSR3 p 81 N87-29872
The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-29012
Folding, articulated, square truss p 40 N87-29859

FOOD
Foods and nutrition in space [SAE PAPER 860926] p 47 A87-38716

FOOD PRODUCTION (IN SPACE)
The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325

FRAGMENTATION
Simulation of on-orbit satellite fragmentations p 140 N87-24515
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics [NASA-CR-179166] p 39 N87-28582

FRAMES
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures — spacecraft masts [NASA-CR-180317] p 38 N87-27280
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures [NASA-CR-4089] p 40 N87-29889

FREE VIBRATION
A Lanczos eigenvalue method on a parallel computer — for large complex space structure free vibration analysis [AIAA PAPER 87-0725] p 13 A87-33585
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures [NASA-CR-4089] p 40 N87-29889

FREQUENCY CONTROL
Modeling and control of flexible structures [AD-A177108] p 29 N87-21389

FREQUENCY DIVISION MULTIPLE ACCESS
FDMA system design and analysis for Space Station p 85 A87-49483

FREQUENCY MODULATION
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel p 113 A87-46488

FREQUENCY RESPONSE
Robust controller design using frequency domain constraints p 11 A87-32229

FREQUENCY SHIFT
Frequency dispersion in the admittance of the polycrystalline Cu2S/CdS solar cell p 5 A87-29120

FRICTION
Self-calibration strategies for robot manipulators p 102 N87-26556

FUEL CELLS
Advanced technology for extended endurance alkaline fuel cells p 75 A87-38767

FUEL TANKS
Temperature fields due to jet induced mixing in a typical OTV tank [AIAA PAPER 87-2017] p 93 A87-52947
Space station experiment definition: Long term cryogenic fluid storage p 94 N87-21144
Design and demonstrate the performance of cryogenic components representative of space vehicles: Start basket liquid acquisition device performance analysis [NASA-CR-179120] p 97 N87-26001

FUNCTIONAL DESIGN SPECIFICATIONS
Comparison of satellite support structure aluminum versus graphite epoxy [SAWE PAPER 1682] p 20 A87-39279

An astrometric facility for planetary detection on the Space Station p 127 A87-50750

Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 128 N87-20625

End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC) -- in-orbiting servicing [FOK-TR-R-86-091-VOL-2] p 102 N87-24486

FUZZY SYSTEMS

Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41617

G

GALACTIC COSMIC RAYS

Radiation shielding requirements on long-duration space missions [AD-A177512] p 140 N87-21991

GALILEO SPACECRAFT

Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-38643

An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets p 45 N87-26192

GALLIUM ARSENIDES

GaAs concentrator solar arrays p 82 N87-29677

Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration p 83 N87-29885

GAME THEORY

Problems of mechanical system configuration control p 149 A87-35877

GAMMA RAY ASTRONOMY

Status of orbital astronomy projects p 128 N87-21973

High energy gamma ray astronomy p 129 N87-24258

GAMMA RAY BURSTS

The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-38443

GAMMA RAYS

Mir in action p 150 A87-37871

GAS DENSITY

Resistojet plume and induced environment analysis [NASA-TM-88857] p 89 N87-24538

GAS EXCHANGE

An evolutionary approach to the development of a CELSS based air revitalization system [SAE PAPER 860968] p 48 A87-38750

GAS TUNGSTEN ARC WELDING

Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 136 N87-20306

GAS-SOLID INTERACTIONS

Proceedings of the NASA Workshop on Atomic Oxygen Effects -- low earth orbital environment [NASA-CR-181163] p 141 N87-26173

Dynamics of atom-surface interactions p 141 N87-26182

Laboratory studies of atomic oxygen reactions with solids p 4 N87-26195

Reactions of atomic oxygen (O(3P)) with polybutadienes and related polymers p 109 N87-26197

Chemical interactions in Low Earth Orbit (LEO) p 109 N87-26199

Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams p 109 N87-26200

Potential surfaces for O atom-polymer reactions p 109 N87-26201

Comments on the interaction of materials with atomic oxygen p 110 N87-26206

GASEOUS ROCKET PROPELLANTS

Hydrogen-oxygen thruster with no products of combustion in exhaust plume [AIAA PAPER 87-1775] p 91 A87-45166

GASES

Gas and water recycling system for IOC vivarium experiments -- Initial Operational Capacity p 48 A87-32457

A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53879

GEOLOGY

Solid Earth panel report -- Columbus program p 157 N87-20836

GEOMAGNETIC MICROPULSATIONS

The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-29942

GEOSYNCHRONOUS ORBITS

Geosynchronous earth orbit base propulsion - Electric propulsion options [AIAA PAPER 87-0990] p 89 A87-38004

Trends in space transportation p 169 A87-41572

The evolution of the geostationary platform concept p 125 A87-43154

An advanced geostationary communications platform p 125 A87-43165

The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-29942

LEO and GEO missions p 5 N87-29916

GET AWAY SPECIALS (STS)

Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 136 N87-20306

Use of lightweight composites for GAS payload structures p 25 N87-20307

Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-20311

The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325

GIMBALS

The Softmounted Inertially Reacting Pointing System (SIRPNT) [AAS PAPER 86-007] p 56 A87-32732

A study on singularity of single gimbal CMG systems p 149 A87-35077

GLASS FIBERS

Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment [AD-A182931] p 110 N87-29709

GLIDE PATHS

Optimal heading change with minimum energy loss for a hypersonic gliding vehicle [AIAA PAPER 87-2569] p 136 A87-49818

GLOBAL POSITIONING SYSTEM

Electric propulsion for orbit transfer - A NAVSTAR case study (Has electric propulsion's time come?) [AIAA PAPER 87-0985] p 88 A87-38001

GPS applications to the Space Station p 136 A87-45525

GOES SATELLITES

Planning for future operational sensors and other priorities [NOAA-NESDIS-30] p 130 N87-25080

GOVERNMENT/INDUSTRY RELATIONS

Space Station business p 169 A87-47726

GRAPHITE

Material damping in aluminum and metal matrix composites p 108 A87-49797

GRAPHITE-EPOXY COMPOSITES

Development of graphite epoxy space structure p 105 A87-32342

Comparison of satellite support structure aluminum versus graphite epoxy [SAWE PAPER 1692] p 20 A87-39279

Joint technology for graphite epoxy space structures p 20 A87-39800

Microcrack resistant structural composite tubes for space applications p 106 A87-41022

Taylored laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794

Box truss antenna technology status p 67 N87-24503

GRAVITATION

Tether system and controlled gravity [AAS PAPER 86-240] p 124 A87-39573

GRAVITATIONAL EFFECTS

Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

Dynamic and thermal effects in very large space structures p 25 N87-20347

Space station momentum management p 64 N87-20988

The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary [NASA-CR-178276] p 8 N87-21020

Equations of motion of a space station with emphasis on the effects of the gravity gradient [NASA-TM-89089] p 64 N87-21930

Verification of large beam-type space structures p 31 N87-22712

Phase 3 study of selected tether applications in space. Volume 1: Executive summary [NASA-CR-179168] p 131 N87-28866

GRAVITATIONAL FIELDS

Optimal shuttle altitude changes using tethers [AD-A179208] p 129 N87-22796

GRAVITATIONAL PHYSIOLOGY

A question of gravity p 1 A87-32116

GRAVITY GRADIENT SATELLITES

Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801

GRAZING INCIDENCE

The Vanderbilt University neutral O-beam facility p 105 A87-38088

The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-26191

GROUND STATE

Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-38624

GROUND TESTS

Validation of large space structures by ground tests p 11 A87-32336

Modeling of environmentally induced transients within satellites [AIAA PAPER 85-0387] p 7 A87-41611

Status of the Mast experiment p 30 N87-22703

Verification of flexible structures by ground test p 31 N87-22713

Ground test of large flexible structures p 34 N87-24510

Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station [NASA-CR-4068] p 36 N87-25808

Development of experimental/analytical concepts for structural design verification -- spacecraft structures [ESA-CR(P)-2343] p 38 N87-26075

Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary -- laboratory test model [ESA-CR(P)-2361-VOL-1] p 73 N87-27707

Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report -- laboratory test model [ESA-CR(P)-2361-VOL-2] p 73 N87-27708

GROWTH

The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325

A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications [NASA-CR-177447] p 130 N87-25787

GYRATION

Dynamics of gyroelastic spacecraft p 59 A87-47811

GYROSCOPES

Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812

GYROSCOPIC STABILITY

Global treatment of energy dissipation effects for multibody satellites p 62 A87-51610

H

HABITABILITY

ISOKIN - A quantitative model of the kinesthetic aspects of spatial habitability p 162 A87-33002

Habitation module for the Space Station [SAE PAPER 860939] p 143 A87-38718

Habitability issues for the Science Laboratory Module [SAE PAPER 860971] p 80 A87-38753

Space station group activities habitability module study [NASA-CR-4010] p 165 N87-21586

HABITATS

The undersea habitat as a space station analog: Evaluation of research and training potential [NASA-CR-180342] p 53 N87-27405

HANDLING EQUIPMENT

Remote handling facility and equipment used for space truss assembly [DE87-009121] p 100 N87-27408

HANGARS

An enclosed hangar concept for large spacecraft servicing at Space Station p 148 A87-32534

HANKEL FUNCTIONS

New time-domain identification technique -- for vibrating structures p 59 A87-43883

HARDWARE

Space Station galley design [SAE PAPER 860892] p 119 A87-38722

Materials for space applications p 108 A87-44741

HARDWARE UTILIZATION LISTS

An evaluation of menu systems for Space Station interfaces p 111 A87-33040

HARMONIC EXCITATION

The effect of nonlinearities on flexible structures [AD-A181736] p 39 N87-27250

HARMONIC OSCILLATION

The effect of nonlinearities on flexible structures [AD-A181736] p 39 N87-27250

HAZARDS

Simulation of on-orbit satellite fragmentations p 140 N87-24815

HAZE

Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002

HEAD-UP DISPLAYS

Head-ported display analysis for Space Station applications p 111 A87-31483

Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 69 A87-31485

191

HEAT BALANCE
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-45642
HEAT EXCHANGERS
Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1626] p 44 A87-43125
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1540] p 44 A87-44843
HEAT PIPES
Determination of the cross-sectional temperature distribution and boiling limitation of a heat pipe
p 40 A87-32175
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32906
HEAT PUMPS
A thermally-pumped heat transport system
p 40 A87-32369
HEAT RADIATORS
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32906
Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system
[SAE PAPER 860969] p 43 A87-38776
Liquid sheet radiator
[AIAA PAPER 87-1525] p 43 A87-43048
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-26936
HEAT STORAGE
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-88886] p 78 N87-22174
HEAT TRANSFER
A two-dimensional numerical heat transfer model for a solar propulsion system p 74 A87-32308
A thermally-pumped heat transport system
p 40 A87-32369
Prototype thermal bus for manned Space Station compartments
[SAE PAPER 861825] p 41 A87-32903
Quality monitoring in two-phase heat transport systems for large spacecraft
[SAE PAPER 860959] p 42 A87-38743
Progress in theory, technology of space materials science p 159 N87-27696
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702
Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-29004
HEAT TRANSMISSION
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125
HERMES MANNED SPACEPLANE
The European space programme p 150 A87-37662
Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-49696
HIGH ALTITUDE
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A176818; p 140 N87-21094
HIGH ENERGY INTERACTIONS
High energy gamma ray astronomy
p 129 N87-24256
HIGH FREQUENCIES
Space Station 20-kHz power management and distribution system p 75 A87-36913
20 kHz Space Station power system
p 76 A87-40979
Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88969] p 68 N87-23680
HIGH TEMPERATURE
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-88886] p 78 N87-22174
HIGH TEMPERATURE PLASMAS
Status of orbital astronomy projects
p 128 N87-21073
HIGH VOLTAGES
Coaxial tube array space transmission line characterization
[NASA-TM-88904] p 66 N87-22009
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182689] p 81 N87-29169
High power solar array technologies — Columbus space station p 82 N87-29975
HISTORIES
Priorities and policy analysis - A response to Alex Roland p 168 A87-41222
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-006467] p 171 N87-22687
HOLLOW CATHODES
Hollow cathode-based plasma contactor experiments for electrodynamic tether
[AIAA PAPER 87-0572] p 121 A87-32192
Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22508
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180922] p 129 N87-22506
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-29591
HONEYCOMB STRUCTURES
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32906
HOOP COLUMN ANTENNAS
Robust controller synthesis for a large flexible space antenna p 64 A87-32225
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021
Controls-structures-electromagnetics interaction program p 69 N87-24502
Hoop/column and tetrahedral truss electromagnetic tests p 67 N87-24504
Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178289] p 10 N87-24709
A spline-based parameter and state estimation technique for static models of elastic surfaces
[NASA-CR-180449] p 11 N87-30107
HOUSINGS
Preloadable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 181 N87-25582
HUBBLE SPACE TELESCOPE
Hubble Space Telescope satellite servicing
[SAE PAPER 861786] p 133 A87-32844
Qualification of the faint object camera
p 127 N87-20959
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 9 N87-22735
HUMAN BEINGS
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 860969] p 164 A87-38751
HUMAN FACTORS ENGINEERING
Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volumes 1 & 2
p 162 A87-33001
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 118 A87-33003
A comparison between space suited and unsuited reach envelopes p 47 A87-33013
Human performance in space p 162 A87-33021
Human factors standards for space habitation
p 162 A87-33022
Planning for unanticipated satellite servicing teleoperations p 118 A87-33048
User interface design guidelines for expert troubleshooting systems — for Space Station
p 6 A87-33060
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724
Space suit reach and strength envelope considerations
[SAE PAPER 860950] p 48 A87-38737
Human capabilities in space
[AAS PAPER 86-114] p 166 A87-53089
Space station group activities habitability module study
[NASA-CR-4010] p 166 N87-21505
Private commentary, photos of Mir orbital station
p 159 N87-27686
HUMAN PERFORMANCE
Human performance in space p 162 A87-33021
Workshop on Workload and Training, and Examination of their Interactions: Executive summary
[NASA-TM-89400] p 171 N87-28760
HUMAN TOLERANCES
A question of gravity p 1 A87-22116
HUMAN WASTES
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860985] p 50 A87-38764
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38794
HYDRAULIC EQUIPMENT
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
HYDRAZINE ENGINES
Thermal design of a large spacecraft propulsion system
[AIAA PAPER 87-1863] p 44 A87-45258
Propulsion recommendations for space station free flying platforms p 96 N87-26129
HYDROGEN
Hydrogen/oxygen economy for the space station
p 96 N87-26130
HYDROGEN ENGINES
Hydrogen-oxygen thruster with no products of combustion in exhaust plume
[AIAA PAPER 87-1775] p 91 A87-45196
HYDROGEN OXYGEN ENGINES
Space station propulsion system technology
[NASA-TM-100106] p 87 N87-25422
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 98 N87-26133
HYDROGEN OXYGEN FUEL CELLS
Advanced fuel cell concepts for future NASA missions
p 86 N87-29030
HYGIENE
Space Station personal hygiene study
[SAE PAPER 860931] p 165 A87-38721
HYPERBARIC CHAMBERS
Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation
[SAE PAPER 860927] p 163 A87-38717
HYPERSONIC VEHICLES
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2566] p 136 A87-49818
HYPERVELOCITY IMPACT
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-26882

I

ICE REPORTING
Ocean-ice panel report — International Space Station
p 156 N87-20836
IMAGE ANALYSIS
SOT: A rapid prototype using TAE windows
p 114 N87-23181
IMAGE CORRELATORS
Optical correlator use at Johnson Space Center
p 59 A87-42866
IMAGE PROCESSING
Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986
[SPIE-644] p 125 A87-44176
Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-48158
Engineering graphics and image processing at Langley Research Center p 10 N87-29129
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89386] p 116 N87-29144
Flight array processor p 116 N87-29148
Video image processing p 116 N87-29150
IMAGE RECONSTRUCTION
Coded mask telescopes for X-ray astronomy
p 123 A87-37765
IMAGE RESOLUTION
Conceptual design of the High-Resolution Imaging Spectrometer (HIRIS) for EOS p 126 A87-44185
IMAGING SPECTROMETERS
Conceptual design of the High-Resolution Imaging Spectrometer (HIRIS) for EOS p 126 A87-44185
Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS
p 126 A87-44186
IMMUNOASSAY
Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26700
IMPACT DAMAGE
Space station integrated wall design and penetration damage control
[NASA-CR-179166] p 38 N87-26881

Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-28582
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179167] p 4 N87-28583
Micrometeorite impact on solar panels -- ESA telecommunication satellites p 82 N87-28981
IMPACT TESTS
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179167] p 4 N87-28583
IMPEDANCE
The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42585
IN-FLIGHT MONITORING
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33755
INDEXES (DOCUMENTATION)
Technology for Large Space Systems. A bibliography with indexes (supplement 17)
[NASA-SP-7046(17)] p 39 N87-29576
INDIAN SPACECRAFT
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-29006
INDIUM
Surface modification to minimise the electrostatic charging of Kapton in the space environment
p 87 N87-28959
INDIUM COMPOUNDS
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets
p 45 N87-28182
INELASTIC SCATTERING
Dynamics of atom-surface interactions
p 141 N87-28183
INERTIAL NAVIGATION
The Softmounted Inertially Reacting Pointing System (SIRPNT)
[AAS PAPER 86-007] p 56 A87-32732
INERTIAL UPPER STAGE
The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0691] p 58 A87-39944
INFECTIOUS DISEASES
Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26703
INFLATABLE STRUCTURES
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
INFORMATION FLOW
Information network architectures p 116 N87-29149
INFORMATION MANAGEMENT
Technical and Management Information System (TMIS)
[AIAA PAPER 87-2217] p 114 A87-48600
INFORMATION SYSTEMS
Japanese space information system overview
[AIAA PAPER 87-2191] p 153 A87-48579
Scientific customer needs - NASA user
[AIAA PAPER 87-2198] p 119 A87-48582
Data management standards for space information systems
[AIAA PAPER 87-2205] p 113 A87-48590
Integrated scheduling and resource management -- for Space Station Information System
[AIAA PAPER 87-2213] p 119 A87-48597
Technical and Management Information System (TMIS)
[AIAA PAPER 87-2217] p 114 A87-48600
Evolution of data management systems from Spacelab to Columbus
[AIAA PAPER 87-2227] p 154 A87-48605
Space Station Information System integrated communications concept
[AIAA PAPER 87-2228] p 114 A87-48606
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2229] p 114 A87-48607
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[GAO/IMTEC-87-20] p 137 N87-22561
Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817
INFRARED ASTRONOMY
Infra-red astronomy after IRAS p 127 A87-54187
INFRARED INSTRUMENTS
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860939] p 150 A87-36729
INFRARED RADIATION
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-48862
INFRARED SPACE OBSERVATORY (ISO)
Infra-red astronomy after IRAS p 127 A87-54187
INFRARED TELESCOPES
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236
Infra-red astronomy after IRAS p 127 A87-54187
INORGANIC COMPOUNDS
Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-28179
INSULATION
Radiation charging and breakdown of insulators
p 143 N87-28954
INTEGRATED OPTICS
Information network architectures p 116 N87-29149
INTELSAT SATELLITES
Analysis of Intelsat V flight data
[AIAA PAPER 87-0784] p 16 A87-33679
INTERACTIVE CONTROL
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 9 N87-22716
Flexible spacecraft simulator p 31 N87-22718
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721
Structural dynamics system model reduction
p 32 N87-22727
NASA/DOD Control/Structures Interaction Technology, 1986
[NASA-CP-2447-PT-2] p 34 N87-24486
Controls-structures-electromagnetics interaction program p 69 N87-24502
Control technology overview in CSI
p 69 N87-24507
INTERCOSMOS SATELLITES
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6
p 147 A87-32914
INTERFACES
Proof that timing requirements of the FDDI token ring protocol are satisfied -- fiber distributed data interface
p 112 A87-42821
New power processor interfaces MMS power module outputs -- Multimission Modular Spacecraft
p 77 A87-48264
INTERFACIAL TENSION
Demands imposed on a surface tension propellant tank due to refuelability in the microgravity environment of outer space
[DGLR PAPER 86-104] p 80 A87-38756
INTERNATIONAL COOPERATION
Geostationary platforms - An international perspective
p 121 A87-32269
Space Station - Overview of the European concept of Columbus programme status and content
p 145 A87-32529
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6
p 147 A87-32914
International cooperation in space
p 149 A87-34894
Flunking on Space Station cooperation?
p 150 A87-37894
The Space Station overview p 168 A87-41571
Trends in space transportation p 168 A87-41572
Man's role in space exploration and exploitation
p 169 A87-48232
Operational instruments on the Space Station-Polar Platforms - Contributions by NOAA and the international community p 127 A87-53149
The GDR and the Soviet space program - The optical instrument sector of the GDR contributions
p 156 A87-53559
Cooperation between Europe and the United States in space (The Fulbright 40th Anniversary Lecture)
p 170 A87-53924
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-266] p 129 N87-20821
Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects)
p 129 N87-20881
USA-Europe coordination and cooperation activities: Announcements of Opportunity -- polar platforms
p 170 N87-20882
INTERNATIONAL LAW
The station is raising lots of questions about space law p 167 A87-34597
Space stations and the law: Selected legal issues
[PB87-118220] p 171 N87-21754
INTERNATIONAL RELATIONS
Cooperation between Europe and the United States in space (The Fulbright 40th Anniversary Lecture)
p 170 A87-53924
INTERORBITAL TRAJECTORIES
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31681
INTERPLANETARY FLIGHT
A survey of tether applications to planetary exploration
[AAS PAPER 86-206] p 123 A87-38568
Prospects for space science
[AAS PAPER 86-108] p 170 A87-53085
Technology projections and space systems opportunities for the 2000-2030 time period
[AAS PAPER 86-109] p 2 A87-53086
INTERPLANETARY SPACE
Radiation shielding requirements on long-duration space missions
[AD-A177512] p 140 N87-21991
INTERPLANETARY SPACECRAFT
Space Station options for constructing advanced solar sails capable of multiple Mars missions
[AIAA PAPER 87-1802] p 91 A87-45287
INVERTED CONVERTERS (DC TO AC)
20 kHz Space Station power system
p 76 A87-40378
Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2318] p 79 N87-24533
ION ENGINES
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015
Ion thrusters advance p 93 A87-54186
ION IMPLANTATION
Surface modification to minimise the electrostatic charging of Kapton in the space environment
p 87 N87-28959
ION SCATTERING
Ram ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51713
IONOSPHERIC PROPAGATION
Design of a beacon receiving system for the Olympus satellite p 88 A87-50157

J

JAPANESE SPACE PROGRAM
Japanese space program p 143 A87-32265
Space Station program in a long-range space development scenario of Japan p 145 A87-32530
Development of exposed deck of Japanese experiment module p 145 A87-32532
Japanese experiment module data management and communication system p 147 A87-32542
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570
Japan's space development programs for communications - An overview p 152 A87-43188
Japanese space information system overview
[AIAA PAPER 87-2191] p 153 A87-48579
Japanese customer needs for Space Station
[AIAA PAPER 87-2188] p 153 A87-48580
JAPANESE SPACECRAFT
Status of Japanese Experiment Module design
p 146 A87-32531
Japanese data relay satellite system
[AIAA PAPER 87-2169] p 154 A87-48566
JET MIXING FLOW
Mixing-induced ullage condensation and fluid destratification
[AIAA PAPER 87-2016] p 82 A87-45867
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 83 A87-52947
JOINTS (JUNCTIONS)
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-34709
Joint technology for graphite epoxy space structures
p 20 A87-35850
Development of precision structural joints for large space structures p 23 N87-22074
Modeling of joints for the dynamic analysis of truss structures
[NASA-TP-2661] p 28 N87-22087
Dynamics of trusses having nonlinear joints
p 32 N87-22734

Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 56 N87-22729
Experimental characterization of deployable trusses and joints p 33 N87-22749
Box truss antenna technology status p 67 N87-24503
Response of joint dominated space structures
[NASA-CR-180564] p 36 N87-26071
Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180633] p 37 N87-26065
Response of joint dominated space structures
[NASA-CR-181202] p 37 N87-26267
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts
[NASA-CR-180317] p 38 N87-27280
Preloaded space structural coupling joints
[NASA-CASE-LAR-13489-1] p 38 N87-27713
Space Station alpha joint bearing p 93 N87-29862

K

KALMAN FILTERS
Square root state estimator for large space structures
[AIAA PAPER 87-2389] p 24 A87-50473
KAPTON (TRADEMARK)
The Vanderbilt University neutral O-beam facility p 105 A87-32059
Surface modification to minimize the electrostatic charging of Kapton in the space environment p 87 N87-28959
MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 92 N87-29880
KINEMATICS
Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22748
KINESTHESIA
ISOKIN - A quantitative model of the kinesthetic aspects of spatial habitability p 162 A87-33002
KINETIC ENERGY
System identification for large space structure damage assessment p 33 N87-22750
KINETICS
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25356

L

L-SAT
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860998] p 150 A87-38720
Modal-survey testing of the Olympus spacecraft p 152 A87-42288
Design of a beacon receiving system for the Olympus satellite p 66 A87-50157
LABORATORIES
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet
[NASA-TM-89894] p 98 N87-22237
LAGRANGIAN EQUILIBRIUM POINTS
Space colonization - T minus 20 (years) and holding p 160 A87-32288
Stability in the relative equilibrium positions of space stations at triangular libration points in the photogravitational three-body problem p 1 A87-38502
LAMINATES
Tapered laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794
LARGE SCALE INTEGRATION
SS focused technology: Gateways and NOS's p 117 N87-29166
LARGE SPACE STRUCTURES
Fiber-optic monitors for space structures p 11 A87-31606
Control operations in advanced aerospace systems p 34 A87-32117
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32120
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLFF method p 144 A87-32304
Validation of large space structures by ground tests p 11 A87-32305
A review of modeling techniques for the open and closed-loop dynamics of large space systems p 12 A87-32337
Modal study of simple masts -- for space applications p 144 A87-32339
Design consideration of mechanical and deployment properties of a coilable lattice mast p 12 A87-32340
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341
Development of graphite epoxy space structure p 105 A87-32342
Local control for large space structures p 54 A87-32440
A consideration to vibration control for a large space structures p 54 A87-32441
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443
Vibration control for a linked system of flexible structures p 55 A87-32444
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
An enclosed hangar concept for large spacecraft servicing at Space Station p 140 A87-32534
Study of actuator for large space manipulator arm p 12 A87-32545
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32546
MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32639
An assessment of recent advances in modeling and control design of space structures under uncertainty
[SAE PAPER 861818] p 147 A87-32656
Static shape control for flexible structures
[SAE PAPER 861822] p 12 A87-32658
Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 861829] p 41 A87-32662
Environmental avoidance concepts for steerable Space Station radiators
[SAE PAPER 861831] p 41 A87-32665
Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 p 56 A87-32728
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32729
Low-authority control through passive damping
[AAS PAPER 86-004] p 56 A87-32730
Solar array flight dynamic experiment
[AAS PAPER 86-020] p 75 A87-32747
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33584
A Lanczos eigenvalue method on a parallel computer -- for large complex space structure free vibration analysis
[AIAA PAPER 87-0725] p 13 A87-33585
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33610
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33611
Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0825] p 14 A87-33613
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0869] p 14 A87-33632
On orbit damage assessment for large space structures
[AIAA PAPER 87-0870] p 15 A87-33634
Design considerations for a one-kilometer antenna mast
[AIAA PAPER 87-0871] p 15 A87-33635
Identification of the zero-g shape of a space beam
[AIAA PAPER 87-0872] p 15 A87-33636
Dynamical response to pulse excitations in large space structures
[AIAA PAPER 87-0716] p 15 A87-33663
Vibration suppression using a constrained rate-feedback Threshold control strategy -- for large space structures
[AIAA PAPER 87-0741] p 6 A87-33665
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33670
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure
[AIAA PAPER 87-0885] p 16 A87-33689
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0903] p 17 A87-33712
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 88 A87-33713
High speed simulation of multi-flexible-body systems with large rotations
[AIAA PAPER 87-0930] p 57 A87-33730
An experimental study of transient waves in a plane grid structure
[AIAA PAPER 87-0943] p 18 A87-33741
Wave propagation in periodic truss structures
[AIAA PAPER 87-0944] p 18 A87-33742
Localization of vibrations in large space reflectors
[AIAA PAPER 87-0948] p 18 A87-33745
On sine dwell or broadband methods for modal testing
[AIAA PAPER 87-0981] p 18 A87-33752
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 18 A87-33755
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-34487
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0801] p 19 A87-34701
A study on singularity of single gimbal CMG systems p 149 A87-35077
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts p 19 A87-35327
Composite tubes for the Space Station truss structure p 20 A87-36601
Quality monitoring in two-phase heat transport systems for large spacecraft
[SAE PAPER 860958] p 42 A87-38743
Control of flexible structures by applied thermal gradients p 21 A87-39643
The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0891] p 58 A87-39644
Deployment dynamics of space structures p 58 A87-40074
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures p 21 A87-40075
New time-domain identification technique -- for vibrating structures p 58 A87-40088
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41813
Inadequacy of single-impulse transfers for path constrained rendezvous p 80 A87-41815
Interdisciplinary analysis procedures in the modeling and control of large space-based structures p 22 A87-42879
A proposal for space tether damage indication, location, and evaluation - The Repair Monkey Module p 125 A87-42884
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46801
An approach to structure/control simultaneous optimization for large flexible spacecraft p 22 A87-46789
Space Station business p 169 A87-47729
Robust multivariable control of large space structures using positivity p 59 A87-47810
Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812
Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50393
Construction of positive real compensation for LSS control -- applied to Large Space Structure model
[AIAA PAPER 87-2239] p 60 A87-50404
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2240] p 60 A87-50413
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 60 A87-50415
Robust eigensystem assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416
Robust control of a large space antenna
[AIAA PAPER 87-2253] p 60 A87-50417
Active damping control design for the COFS Mast Flight System -- Control of Flexible Structures program for NASA
[AIAA PAPER 87-2321] p 23 A87-50442
Active vibration control synthesis for the COFS-I - A classical approach -- Control of Flexible Structures experiment for NASA
[AIAA PAPER 87-2322] p 23 A87-50443
Suboptimal feedback vibration control of a beam with a proof-mass actuator -- large space structures
[AIAA PAPER 87-2323] p 23 A87-50444
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445

Square root state estimator for large space structures
[AIAA PAPER 87-2389] p 24 A87-50473

An analytical and experimental investigation of output feedback vs. linear quadratic regulator -- for large space structures
[AIAA PAPER 87-2390] p 61 A87-50474

Comparison of different attitude control schemes for large communications satellites
[AIAA PAPER 87-2391] p 61 A87-50475

Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2596] p 62 A87-50558

Space Station - All change? p 154 A87-50792

Global treatment of energy dissipation effects for multibody satellites p 62 A87-51810

Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries
p 107 A87-51772

Development of full scale deployable CFRP truss for space structure p 25 A87-51793

Equations of motion for maneuvering flexible spacecraft p 63 A87-52985

Identification of large space structures - A factorization approach p 25 A87-52988

Model reference adaptive control for large structural systems p 63 A87-52973

Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit
[NASA-TM-89118] p 88 N87-20339

Dynamic and thermal effects in very large space structures p 25 N87-20347

Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 26 N87-20348

Large space antennas: A systems analysis case history
[NASA-TM-89072] p 26 N87-20352

Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A179529] p 26 N87-20355

Future trends in spacecraft design and qualification
p 2 N87-20356

Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357

Dynamic modelling and optimal control design for large flexible space structures p 26 N87-20358

Structural qualification of large spacecraft
p 26 N87-20361

Effect of modal damping in modal synthesis of spacecraft structures p 26 N87-20362

Active structural controllers emulating structural elements by ICUs p 27 N87-20367

Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20368

Influence co-efficient testing as a substitute for modal survey testing of large space structures
p 27 N87-20369

Benefits of passive damping as applied to active control of large space structures p 63 N87-20371

Development of precision structural joints for large space structures p 28 N87-20374

Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 63 N87-20380

Modeling of joints for the dynamic analysis of truss structures
[NASA-TP-2661] p 29 N87-20567

Space station structures and dynamics test program
[NASA-TP-2710] p 29 N87-20568

The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Blast and Ground Shock, Shock Testing and Analysis
[AD-A178284] p 29 N87-20574

Air Force basic research in dynamics and control of large space structures p 63 N87-20577

Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 6 N87-20581

Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021

Measurement apparatus and procedure for the determination of surface emissivities
[NASA-CASE-LAR-13455-1] p 29 N87-21258

Comparison of wave-mode coordinate and pulse summation methods
[AD-A177785] p 30 N87-21602

Structural concepts for large solar concentrators
[NASA-CR-4075] p 86 N87-21604

Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 30 N87-22298

Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-1] p 65 N87-22702

Status of the Mast experiment p 30 N87-22703

Large space structures ground experiment checkout
p 30 N87-22704

Identification of large space structures: A state-of-practice report p 31 N87-22705

Considerations in the design and development of a space station scale model p 9 N87-22711

Verification of large beam-type space structures
p 31 N87-22712

Verification of flexible structures by ground test
p 31 N87-22713

Optimum mix of passive and active control of space structures p 65 N87-22714

One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715

Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 9 N87-22716

Status report and preliminary results of the spacecraft control laboratory experiment p 66 N87-22717

An overview of controls research on the NASA Langley Research Center grid p 66 N87-22720

Precision pointing and control of flexible spacecraft
p 66 N87-22723

Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 68 N87-22729

Vibration suppression by stiffness control
p 68 N87-22730

Control of flexible structures and the research community p 68 N87-22732

A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 9 N87-22735

High speed simulation of flexible multibody dynamics
p 33 N87-22738

Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741

A new approach for vibration control in large space structures p 33 N87-22743

Modeling of controlled flexible structures with impulsive loads p 33 N87-22745

On the control of structures by applied thermal gradients p 33 N87-22747

System identification for large space structure damage assessment p 33 N87-22750

Adaptive momentum management for large space structures
[NASA-CR-179088] p 67 N87-22758

An integrated, optimization-based approach to the design and control of large space structures
[AD-A179450] p 34 N87-23085

Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88926] p 69 N87-23880

Modified independent modal space control method for active control of flexible systems
[NASA-CR-181085] p 34 N87-23890

Guidelines for noise and vibration levels for the space station
[NASA-CR-178310] p 120 N87-24162

Robust control for large space antennas
p 87 N87-24489

Large space systems technology and requirements
p 3 N87-24500

Controls-structures-electromagnetics interaction program p 69 N87-24502

Hoop/column and tetrahedral truss electromagnetic tests p 87 N87-24504

COFS 3 multibody dynamics and control technology
p 69 N87-24506

Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24508

Structural control by the use of piezoelectric active members p 69 N87-24509

Ground test of large flexible structures
p 34 N87-24510

Slew maneuvers on the SCOLE Laboratory Facility
p 69 N87-24511

Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179735] p 35 N87-24517

Large space structures testing
[NASA-TM-100333] p 35 N87-24520

Distributed control using linear momentum exchange devices
[NASA-TM-100308] p 70 N87-24521

Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178080] p 10 N87-24709

Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-88994] p 70 N87-24725

Design, development and fabrication of a deployable/retractable truss beam model for large space structures application
[NASA-CR-178287] p 35 N87-25349

Some problems in the control of large space structures
[AD-A178968] p 70 N87-25350

Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180606] p 71 N87-25352

The effects of structural perturbations on decoupled control -- spacecraft p 35 N87-25359

Deployable geodesic truss structure
[NASA-CASE-LAR-13113-1] p 36 N87-25492

Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-25805

Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88295] p 79 N87-25838

Responses of joint dominated space structures
[NASA-CR-180564] p 36 N87-26071

Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180833] p 37 N87-26365

Response of joint dominated space structures
[NASA-CR-181202] p 37 N87-26367

An investigation of methodology for the control and failure identification of flexible structures
p 38 N87-26821

Theory and application of linear servo dampers for large scale space structures p 72 N87-26870

Digital control system for space structure dampers
[NASA-CR-181253] p 72 N87-27704

Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2381-VOL-1] p 73 N87-27706

Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary -- laboratory test model
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707

Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report -- laboratory test model
[ESA-CR(P)-2381-VOL-2] p 73 N87-27708

Study on investigation of the attitude control of large flexible spacecraft, phase 2
[ESA-CR(P)-2381-VOL-4] p 73 N87-27709

The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712

Preloaded space structural coupling joints
[NASA-CASE-LAR-13489-1] p 39 N87-27713

An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-28007

Technology for Large Space Systems. A bibliography with indexes (supplement 17)
[NASA-SP-7046(17)] p 39 N87-28576

The 21st Aerospace Mechanisms Symposium
[NASA-CP-2470] p 103 N87-29868

The design and development of a two-dimensional adaptive truss structure p 40 N87-29860

LASER APPLICATIONS

Solar array flight dynamic experiment
[AAS PAPER 86-090] p 75 A87-32747

Measuring thermal expansion in large composite structures -- for spaceborne telescopes
p 20 A87-33012

Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-35525

Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986
[SPIE-644] p 125 A87-44176

LASER HEATING

Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-29180

LASER OUTPUTS

A high flux pulsed source of energetic atomic oxygen -- for spacecraft materials ground testing
p 139 A87-38823

LASER PLASMAS

High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies
p 105 A87-33580

LASER PROPULSION

Advanced propulsion activities in the USA
p 80 A87-41575

LASER RANGE FINDERS

Rendezvous and docking tracker
[AAS PAPER 86-014] p 130 A87-32733

Laser docking system flight experiment
[AAS PAPER 86-043] p 89 A87-32746

LASER WEAPONS

Joint Optics Structures Experiment (JOSE)
p 94 N87-24497

LATCHES
Preloadable vector sensitive latch [NASA-CASE-MSC-20910-1] p 161 N87-25582
The preloadable vector sensitive latch for orbital docking/berthing p 162 N87-29676
LATTICE PARAMETERS
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures) [AD-A177271] p 30 N87-22256
LATTICES (MATHEMATICS)
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts p 19 A87-25327
Adaptive identification of flexible structures by lattice filters [AIAA PAPER 87-2458] p 24 A87-50504
Comparison of wave-mode coordinate and pulse summation methods [AD-A177795] p 30 N87-21862
LAUNCH VEHICLES
Space launcher upper stages - Design for mission versatility and/or orbital operation p 132 A87-32474
Trends in space transportation p 168 A87-41572
The Soviet space shuttle programme p 153 A87-47302
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29C43
LAYOUTS
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station p 118 A87-33003
LEAST SQUARES METHOD
On-line identification and attitude control for SCOLE [AIAA PAPER 87-2459] p 91 A87-50505
A computer program for model verification of dynamic systems p 31 N87-22710
LENGTH
Optimal shuttle attitude changes using tethers [AD-A178305] p 129 N87-22798
LIAPUNOV FUNCTIONS
Adaptive tracking of dynamical model by uncertain nonlinearizable spacecraft [AIAA PAPER 87-0940] p 57 A87-33738
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control [AIAA PAPER 87-2484] p 93 A87-50509
LIBRATION
Tethered satellite program control strategy [AAS PAPER 86-221] p 123 A87-38570
LIFE (DURABILITY)
Design study of large area 8 cm x 8 cm wraparound cells for space station p 80 N87-26424
LIFE CYCLE COSTS
The multi-disciplinary design study. A life cycle cost algorithm [NASA-CR-178182] p 9 N87-21886
LIFE SCIENCES
Gas and water recycling system for IOC vivarium experiments -- Initial Operational Capacity p 46 A87-32457
Space Station - Opportunities for the life sciences p 122 A87-34871
Special considerations in outfitting a space station module for scientific use [SAE PAPER 860956] p 164 A87-38741
Conceptual planning for Space Station life sciences human research project [SAE PAPER 860969] p 164 A87-38751
Life Sciences Research Facility automation requirements and concepts for the Space Station [SAE PAPER 860970] p 50 A87-38752
Life Science Research Facility materials management requirements and concepts [SAE PAPER 860974] p 124 A87-38756
Soviet space stations as analogs, second edition [NASA-CR-180920] p 157 N87-21888
LIFE SUPPORT SYSTEMS
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station p 46 A87-32544
EDC development and testing for the Space Station program -- Electrochemical Carbon Dioxide Concentration [SAE PAPER 860918] p 118 A87-38710
A Space Station utility - Static Feed Electrolyzer [SAE PAPER 860920] p 47 A87-38712
Space Station environmental control and life support system distribution and loop closure studies [SAE PAPER 860942] p 48 A87-38729
Status of the Space Station environmental control and life support system design concept [SAE PAPER 860943] p 48 A87-38730
Environmental Control Life Support for the Space Station [SAE PAPER 860944] p 48 A87-38731
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements [SAE PAPER 860945] p 48 A87-38732
Integrated air revitalization system for Space Station [SAE PAPER 860946] p 48 A87-38733
Physiological requirements and pressure control of a spacesuit [SAE PAPER 860965] p 150 A87-38747
Columbus Life Support System and its technology development [SAE PAPER 860966] p 150 A87-38748
Life Support Subsystem concepts for botanical experiments of long duration [SAE PAPER 860967] p 49 A87-38749
An evolutionary approach to the development of a CELSS based air revitalization system [SAE PAPER 860968] p 49 A87-38750
Pre- and post-treatment techniques for spacecraft water recovery [SAE PAPER 860982] p 50 A87-38761
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs [SAE PAPER 860987] p 51 A87-38766
Environmental control and life support technologies for advanced manned space missions [SAE PAPER 860994] p 51 A87-38771
An advanced carbon reactor subsystem for carbon dioxide reduction [SAE PAPER 860995] p 51 A87-38772
Integrated waste and water management system [SAE PAPER 860996] p 51 A87-38773
CELSS waste management systems evaluation [SAE PAPER 860997] p 51 A87-38774
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station [SAE PAPER 861007] p 52 A87-38779
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-40358
Complex system monitoring and fault diagnosis using communicating expert systems p 119 A87-40363
Life support subsystem concepts for botanical experiments of long duration [MBB-UR-E-807-86-PUB] p 154 A87-46887
Maintenance evaluation for space station liquid systems p 52 N87-21155
Hydrogen/oxygen economy for the space station p 99 N87-29130
Automated Subsystem Control for Life Support System (ASCLSS) [NASA-CR-172003] p 53 N87-29117
LIGHT EMITTING DIODES
Head-ported display analysis for Space Station applications p 111 A87-31463
LINEAR PROGRAMMING
Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34208
LINEAR QUADRATIC GAUSSIAN CONTROL
Reduced-order compensation - LQG reduction versus optimal projection [AIAA PAPER 87-2388] p 61 A87-50472
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
LINEAR QUADRATIC REGULATOR
An analytical and experimental investigation of output feedback vs. linear quadratic regulator -- for large space structures [AIAA PAPER 87-2390] p 61 A87-50474
Linear quadratic control system design for Space Station pointed payloads [AIAA PAPER 87-2530] p 161 A87-50533
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
LINEAR SYSTEMS
Maximum likelihood identification using an array processor p 5 A87-32121
MOVER II - A computer program for verifying reduced-order models of large dynamic systems [SAE PAPER 861793] p 5 A87-32939
An identification method for flexible structures [AIAA PAPER 87-0745] p 16 A87-33669
Stability of time varying linear systems p 7 A87-37128
Response bounds for linear underdamped systems [ASME PAPER 87-APM-34] p 59 A87-42660
A basis change strategy for the reduced gradient method and the optimum design of large structures p 23 A87-48341
Theory and application of linear servo dampers for large scale space structures p 72 N87-25870
LINEARIZATION
Response of joint dominated space structures [NASA-CR-180564] p 36 N87-26071
Response of joint dominated space structures [NASA-CR-181202] p 37 N87-26387
LINKAGES
Preloadable vector sensitive latch [NASA-CASE-MSC-20910-1] p 161 N87-25582
LIQUID CRYSTALS
Head-ported display analysis for Space Station applications p 111 A87-31463
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-38825
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity [AD-A178867] p 120 N87-22782
LIQUID FUELS
Overview: Fluid acquisition and transfer p 84 N87-21146
LIQUID HELIUM
Transferring superfluid helium in space p 88 A87-34712
Helium technology issues p 84 N87-21145
Superfluid helium on orbit transfer (SHOOT) p 85 N87-21151
LIQUID PROPELLANT ROCKET ENGINES
Liquid propulsion technology for expendable and STS launch vehicle transfer stages [AIAA PAPER 87-1834] p 92 A87-48311
LIQUID ROCKET PROPELLANTS
Mixing-induced ullage condensation and fluid destratification [AIAA PAPER 87-2018] p 92 A87-45357
Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation [AIAA PAPER 87-2021] p 92 A87-45360
An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-25860
LIQUID SLOSHING
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement p 84 N87-21147
LIQUID SURFACES
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-38838
LOAD DISTRIBUTION (FORCES)
Modeling of controlled flexible structures with impulsive loads p 33 N87-22746
LOADING MOMENTS
Structural dynamics system model reduction p 32 N87-22727
LOADS (FORCES)
Structural qualification of large spacecraft p 28 N87-20381
Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22743
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts [NASA-CR-180917] p 38 N87-27260
LOCAL AREA NETWORKS
Star topology spacecraft data bus p 112 A87-37431
GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volumes 1, 2, & 3 p 169 A87-45476
Advanced local area network concepts p 117 N87-29153
Network reliability p 117 N87-29157
LOCKS (FASTENERS)
Collant lock joint for space station truss [NASA-CASE-MSC-21207-1] p 38 N87-28576
LOGIC CIRCUITS
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
LOGISTICS
Space Shuttle flight rates and utilization p 1 A87-37693
LONG DURATION SPACE FLIGHT
A question of gravity p 1 A87-30116
Space Station personal hygiene study [SAE PAPER 860951] p 163 A87-38721
Life Support Subsystem concepts for botanical experiments of long duration [SAE PAPER 860967] p 49 A87-38749
Maintenance components for Space Station long life fluid systems [SAE PAPER 861006] p 89 A87-38778
Effect of long-term exposure to LEO space environment on spacecraft materials p 166 A87-50425

K.E. Tsiolkovskii and problems in the development of science and technology -- Russian book p 151 A87-40342

Life support subsystem concepts for botanical experiments of long duration [MBB-UR-E-907-86-PUB] p 154 A87-48987

Space station experiment definition: Long-term cryogenic fluid storage p 94 N87-21144

Radiation shielding requirements on long-duration space missions [AD-A177512] p 140 N87-21081

Soviet space stations as analogs, second edition [NASA-CR-180920] p 157 N87-21996

Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-26207

LONG TERM EFFECTS

Development of an emulation-simulation thermal control model for space station application [NASA-CR-180312] p 45 N87-25836

LONGERONS

Modal study of simplex masts -- for space applications p 144 A87-32339

Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340

A Lanczos eigenvalue method on a parallel computer -- for large complex space structure free vibration analysis [AIAA PAPER 87-0725] p 13 A87-33565

Deployable geodetic truss structure [NASA-CASE-LAR-13113-1] p 36 N87-25482

LOW DENSITY MATERIALS

Carbon fibre slotted waveguide arrays p 85 A87-41302

LOW FREQUENCIES

Low frequency vibration testing on satellites p 27 N87-20364

LOW GRAVITY MANUFACTURING

Analytical and experimental modeling of zero/low gravity fluid behavior [AIAA PAPER 87-1865] p 91 A87-45260

Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752

Progress in theory, technology of space materials science p 158 N87-27695

LOW THRUST

Status and tendencies for low to medium thrust propulsion systems [IAF PAPER 86-162] p 80 A87-42880

LUBRICATION SYSTEMS

Space Station lubrication considerations p 104 N87-29879

LUMINESCENCE

The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181

Spacecraft ram glow and surface temperature p 10 N87-26205

M

MACH-ZEHNDER INTERFEROMETERS

Fiber-optic monitors for space structures p 11 A87-31505

MAGNESIUM ALLOYS

Material damping in aluminum and metal matrix composites p 108 A87-49787

MAGNETIC COOLING

Magnetic refrigeration for space platforms [SAE PAPER 861724] p 178 A87-32817

MAGNETIC FIELD CONFIGURATIONS

A preliminary study of extended magnetic field structures in the ionosphere [NASA-CR-181004] p 140 N87-23086

MAGNETIC INDUCTION

Thermal and dynamical effects on electrodynamic space tethers [AD-A180276] p 130 N87-25351

MAGNETIC STORAGE

Mass storage systems for data transport in the early space station era 1992-1998 [NASA-TM-87826] p 115 N87-27443

MAGNETIC STORMS

Modeling of environmentally induced transients within satellites [AIAA PAPER 85-0387] p 7 A87-41811

MAGNETOSPHERIC ELECTRON DENSITY

Thick dielectric charging on high altitude spacecraft p 87 N87-26081

MAGNETOSPHERIC INSTABILITY

The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-26042

MAINTAINABILITY

Space Station integration and verification concepts p 84 A87-31461

Autonomous decentralized system concept for Space Station p 146 A87-32541

MAINTENANCE

Advanced EVA system design requirements study: EVAS/space station system interface requirements [NASA-CR-171981] p 120 N87-20351

Maintenance evaluation for space station liquid systems p 52 N87-21155

MAN ENVIRONMENT INTERACTIONS

Human factors standards for space habitation p 162 A87-33022

Effect of crew motions on the spatial position of a spacecraft p 152 A87-41954

MAN MACHINE SYSTEMS

A master-slave manipulator system for space use p 147 A87-32546

Role of the manned maneuvering unit for the Space Station [SAE PAPER 861834] p 133 A87-32667

Human factors standards for space habitation p 162 A87-33022

Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 [SAE P-177] p 162 A87-38701

The development of an EVA Universal Work Station [SAE PAPER 860952] p 164 A87-38739

An evaluation of advanced extravehicular crew enclosures [SAE PAPER 861009] p 134 A87-38781

Space Station EVA using a maneuvering enclosure unit [SAE PAPER 861010] p 135 A87-38782

Robotic telepresence p 100 A87-46704

A multiple attribute decision analysis of manned airlock systems [AD-A178241] p 137 N87-23882

Automated Subsystem Control for Life Support System (ASCLSS) [NASA-CR-172003] p 53 N87-29117

Electronic control/display interface technology p 88 N87-29181

MAN-COMPUTER INTERFACE

An evaluation of menu systems for Space Station interfaces p 111 A87-33040

User interface design guidelines for expert troubleshooting systems -- for Space Station p 6 A87-33050

A hybrid nonlinear programming method for design optimization p 7 A87-35716

Standards for the user interface - Developing a user consensus -- for Space Station Information System [AIAA PAPER 87-2209] p 169 A87-48884

TAE Plus: A conceptual view of TAE in the space station era p 9 N87-23157

SOT: A rapid prototype using TAE windows p 114 N87-23161

MANAGEMENT

Adaptive momentum management for large space structures [NASA-CR-178365] p 67 N87-22758

SAGA: A project to automate the management of software production systems [NASA-CR-180276] p 10 N87-27412

MANAGEMENT ANALYSIS

Innovations in space management - Macromanagement and the NASA heritage p 167 A87-34570

MANAGEMENT METHODS

Innovations in space management - Macromanagement and the NASA heritage p 167 A87-34570

MANAGEMENT SYSTEMS

An operations management system for the Space Station p 112 A87-40858

Communication and Data Management Systems for an orbiting platform p 112 A87-40859

On board Data Management p 112 A87-40861

A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system [AIAA PAPER 87-2487] p 77 A87-50511

MANEUVERABLE SPACECRAFT

A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment [AD-A179108] p 161 N87-23877

MANEUVERS

Lanczos modes for reduced-order control of flexible structures p 30 N87-22739

MANIPULATORS

Control of a flexible space manipulator p 89 A87-32449

Study of actuator for large space manipulator arm p 12 A87-32545

A master-slave manipulator system for space use p 147 A87-32546

Evaluation of constraint stabilization procedures for multibody dynamical systems [AIAA PAPER 87-0927] p 7 A87-33729

Development of harmonic drive actuator for space manipulator p 149 A87-35076

Control of robot manipulator compliance p 100 A87-45797

Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation [DE87-004816] p 101 N87-22231

Traction-drive telerobot for space manipulation [DE87-005326] p 102 N87-22233

Telerobotic technology for nuclear and space applications [NASA-CR-180923] p 102 N87-22242

Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity [AD-A178887] p 120 N87-22782

End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC) -- in-orbiting servicing [FOK-TR-R-86-091-VOL-2] p 102 N87-24488

End effector development study, volume 1 -- in-orbit servicing [FOK-TR-R-86-091-VOL-1] p 102 N87-25336

End effector development study. Volume 3: Appendices -- in-orbit servicing [FOK-TR-R-86-091-VOL-3] p 102 N87-25337

Self-calibration strategies for robot manipulators p 102 N87-26355

The 21st Aerospace Mechanisms Symposium [NASA-CP-2470] p 103 N87-29858

Development of a standard connector for orbital replacement units for serviceable spacecraft p 40 N87-29864

Telerobotic work system: Concept development and evolution p 104 N87-29886

Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 101 N87-29887

MANNED MANEUVERING UNITS

Computer simulation of on-orbit manned maneuvering unit operations [SAE PAPER 861793] p 47 A87-32632

Role of the manned maneuvering unit for the Space Station [SAE PAPER 861834] p 133 A87-32667

The next step for the MMU - Capabilities and enhancements [SAE PAPER 861013] p 160 A87-38783

MANNED ORBITAL LABORATORIES

The Industrial Space Facility p 167 A87-36579

System aspects of Columbus thermal control [SAE PAPER 860930] p 150 A87-38727

Science and payload options for animal and plant research accommodations aboard the early Space Station [SAE PAPER 860953] p 164 A87-38740

The Columbus program: An overview p 158 N87-20823

Military man in space: A history of Air Force efforts to find a manned space mission [AD-A178873] p 171 N87-25815

Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary [ESA-CR(P)-2230] p 158 N87-27689

MANNED SPACE FLIGHT

A question of gravity p 1 A87-32116

Prototype thermal bus for manned Space Station components [SAE PAPER 861825] p 41 A87-32658

Manned space flight -- comparisons between U.S. and U.S.S.R. programs p 167 A87-33019

When the doctor is 200 miles away p 47 A87-35800

Mir in action p 150 A87-37671

Results on reuse of reclaimed shower water [SAE PAPER 860983] p 50 A87-38762

Environmental control and life support technologies for advanced manned space missions [SAE PAPER 860994] p 51 A87-38771

Integrated waste and water management system [SAE PAPER 860998] p 51 A87-38773

An improved waste collection system for space flight [SAE PAPER 861014] p 119 A87-38784

Europe prepares for manned orbital operations p 151 A87-39994

Legal problems concerning manned space flight -- Russian book p 151 A87-40339

Priorities and policy analysis - A response to Alex Roland p 169 A87-41222

Man's role in space exploration and exploitation p 169 A87-46862

Mir - A second Sputnik? p 153 A87-48872

Radiation environments and absorbed dose estimations on manned space missions p 139 A87-49026

The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53062

Human capabilities in space
[AAS PAPER 86-114] p 165 A87-53069

Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732

National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-25024

USSR Report: Space
[JPRS-USP-86-004] p 158 N87-27687

MANNED SPACECRAFT

Manned spacecraft electrical power systems p 75 A87-37291

Manned spacecraft automation and robotics p 100 A87-37300

Flunking on Space Station cooperation? p 150 A87-37984

Military space station implications
[AD-A180831] p 172 N87-26664

MANY BODY PROBLEM

Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-43867

Global treatment of energy dissipation effects for multibody satellites p 62 A87-51610

High speed simulation of flexible multibody dynamics p 33 N87-22739

MARITIME SATELLITES

The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-29975

MASS

Mass property estimation for control of asymmetrical satellites p 63 A87-52999

MASS DISTRIBUTION

Optimization of payload mass placement in a dual keel space station
[NASA-TM-89051] p 66 N87-23687

MASS FLOW RATE

The liquid droplet radiator in space: A parametric approach
[AD-A182605] p 46 N87-29217

MASS SPECTROMETERS

Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements p 108 N87-26173

Mass spectrometers and atomic oxygen p 141 N87-26176

MASS TRANSFER

Progress in theory, technology of space materials science p 158 N87-27695

MATERIALS HANDLING

Life Science Research Facility materials management requirements and concepts
[SAE PAPER 860974] p 124 A87-38758

An evaluation of candidate oxidation resistant materials for space applications in LEO
[NASA-TM-100122] p 107 N87-25480

MATERIALS TESTS

A space debris simulation facility for spacecraft materials evaluation p 11 A87-32059

The Vanderbilt University neutral O-beam facility p 105 A87-32069

Selected materials issues associated with Space Station p 105 A87-32081

A high flux pulsed source of energetic atomic oxygen — for spacecraft materials ground testing p 139 A87-36623

Materials for space applications p 106 A87-44741

Testing of materials for solar power space applications p 107 A87-53046

MATHEMATICAL MODELS

An assessment of recent advances in modeling and control design of space structures under uncertainty
[SAE PAPER 861616] p 147 A87-33066

An identification method for flexible structures
[AIAA PAPER 87-0745] p 16 A87-33669

System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33670

A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574

Modeling and control of torsional vibrations in a flexible structure p 60 A87-50093

Dynamic and thermal effects in very large space structures p 25 N87-20947

Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-22068

Modeling and control of flexible structures p 29 N87-20694

Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-20581

Numerical modelling of cryogenic propellant behavior in low-G p 95 N87-21148

Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180622] p 129 N87-22509

Identification of large space structures: A state-of-practice report p 31 N87-22705

A general method for dynamic analysis of structures overview p 31 N87-22707

Verification of flexible structures by ground test p 31 N87-22713

A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731

Control of flexible structures and the research community p 66 N87-22732

Lanczos modes for reduced-order control of flexible structures p 23 N87-22736

Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741

Modeling of controlled flexible structures with impulsive loads p 33 N87-22745

On the control of structures by applied thermal gradients p 33 N87-22747

Experimental characterization of deployable trusses and joints p 33 N87-22749

System identification for large space structure damage assessment p 33 N87-22750

Space station structures and dynamics test program p 33 N87-22751

Space station structural dynamics/reaction control system interaction study p 67 N87-22753

Moving-bank multiple model adaptive estimation applied to flexible spacestructure control
[AD-A178870] p 69 N87-23761

An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A179235] p 69 N87-23881

Large spacecraft pointing and shape control p 69 N87-24469

Application of physical parameter identification to finite-element models p 34 N87-24505

Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180391] p 70 N87-24513

Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801

Minimum line attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26039

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702

Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-29004

Vibrations and structureborne noise in space station
[NASA-CR-181281] p 39 N87-29595

Space Electrochemical Research and Technology (SERT)
[NASA-CP-2484] p 5 N87-29814

MATRICES (MATHEMATICS)

New time-domain identification technique — for vibrating structures p 59 A87-46959

Projection filters for modal parameter estimate for flexible structures
[NASA-CR-180203] p 38 N87-26563

MATRIX MATERIALS

Material damping in aluminum and metal matrix composites p 106 A87-48797

MATRIX METHODS

Wave propagation in periodic truss structures
[AIAA PAPER 87-0944] p 16 A87-33742

Comparison of the Craig-Bampton and residual flexibility methods of substructure representation p 19 A87-34510

MAXIMUM ENTROPY METHOD

Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741

MAXIMUM LIKELIHOOD ESTIMATES

Maximum likelihood identification using an array processor p 5 A87-32121

Maximum likelihood parameter identification of flexible spacecraft
[ETN-87-90236] p 39 N87-27706

MECHANICAL DEVICES

Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812

MECHANICAL DRIVES

Traction-drive telerobot for space manipulation
[DE87-005320] p 102 N87-22233

Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 103 N87-25118

Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-29867

Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29868

Common drive unit p 104 N87-29869

MECHANICAL PROPERTIES

Composite space antenna structures - Properties and environmental effects p 20 A87-38810

PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44586

MECHANICS (PHYSICS)

U.S. National Congress of Applied Mechanics, 10th, University of Texas, Austin, June 16-20, 1986, Proceedings
[AD-A181952] p 1 A87-43051

MEDICAL EQUIPMENT

When the doctor is 200 miles away p 47 A87-35800

MELTS (CRYSTAL GROWTH)

Progress in theory, technology of space materials science p 158 N87-27695

MENTAL PERFORMANCE

Workshop on Workload and Training, and Examination of their Interactions: Executive summary
[NASA-TM-89459] p 171 N87-25760

METAL FILMS

Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182801] p 110 N87-29728

METAL MATRIX COMPOSITES

Material damping in aluminum and metal matrix composites p 106 A87-48797

Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries p 107 A87-51772

METAL OXIDES

Oxidation protection coatings for polymers
[NASA-CASE-LEW-14072-2] p 107 N87-25736

METAL PLATES

Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32083

Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860878] p 42 A87-38760

METAL SURFACES

On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit p 159 N87-29883

METEORITIC DAMAGE

Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870

Micrometeorite impact on solar panels — ESA telecommunication satellites p 82 N87-29991

Micrometeorite exposure of solar arrays p 82 N87-29992

METEOROLOGICAL RADAR

Observation of precipitation from space by the weather radar p 145 A87-32507

MICROCRACKS

Assessment of space environment induced microdamage in toughened composite materials p 20 A87-36809

Microcrack resistant structural composite tubes for space applications p 109 A87-41022

MICROGRAVITY APPLICATIONS

On the dynamical stability of the space 'monorail' p 149 A87-34047

Tether system and controlled gravity
[AAS PAPER 86-240] p 124 A87-36673

Symposium on Microgravity Fluid Mechanics, Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 p 89 A87-38795

A three-mass tethered system for micro-g/variable-g applications p 125 A87-40559

Japanese Experiment Module (JEM) preliminary design status p 151 A87-41575

Analytical and experimental modeling of zero/low-gravity fluid behavior
[AIAA PAPER 87-1000] p 91 A87-45880

Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2165] p 153 A87-48991

Microgravity experiments onboard Foton p 155 A87-53054

MICROMETEOROIDS

Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870

MICROMETEOROIDS

Micrometeorite impact on solar panels — ESA telecommunication satellites p 82 N87-29991

Micrometeorite exposure of solar arrays p 82 N87-29992

MICROPROCESSORS
Microprocessor controlled proof-mass actuator
p 65 N87-22706
MICROWAVE ANTENNAS
Design of a beacon receiving system for the Olympus satellite p 86 A87-50157
MICROWAVE TRANSMISSION
Shape control of the directional pattern in a microwave-beam power transmission channel
p 148 A87-34345
MILITARY OPERATIONS
Present and future military uses of outer space: International law, politics, and the practice of states
[AD-A176722] p 170 N87-21753
Military space station implications
[AD-A180831] p 172 N87-26694
MILITARY SPACECRAFT
The benefit of phase change thermal storage for spacecraft thermal management
[AIAA PAPER 87-1482] p 43 A87-43014
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-008487] p 171 N87-22597
Military space station implications
[AD-A180831] p 172 N87-26694
MILITARY TECHNOLOGY
1987 status report - United States Air Force electric propulsion research and development
[AIAA PAPER 87-1038] p 90 A87-41122
Spacecraft environment interaction investigation
[AD-A179183] p 140 N87-23679
MINIMAX TECHNIQUE
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31681
MIR SPACE STATION
Mir - A second Sputnik? p 153 A87-46672
USSR Report: Space
[JPRS-USP-86-004] p 156 N87-27667
Pravda commentary, photos of Mir orbital station
p 159 N87-27686
MIRRORS
Design considerations for long-lived glass mirrors for space p 123 A87-38031
Optical correlator use at Johnson Space Center
p 59 A87-42656
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445
MISSION PLANNING
Hubble Space Telescope satellite servicing
[SAE PAPER 861788] p 133 A87-32844
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements
[SAE PAPER 860945] p 48 A87-38732
Europe prepares for manned orbital operations
p 151 A87-38684
Columbus/Space Station United Kingdom Utilisation Study 1985/6 Report - Executive Summary
p 151 A87-41429
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48802
From Eureca-A to Eureca-B p 155 A87-53916
Satellite servicing mission preliminary cost estimation model
[NASA-CR-171979] p 132 N87-20335
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340
High power/large area PV systems
p 80 N87-25452
Phase II study of selected tether applications in space. Volume 1: Executive summary
[NASA-CR-179165] p 131 N87-25584
LEO and GEO missions p 5 N87-25916
JPL future missions and energy storage technology implications p 84 N87-25917
MIXING
Mixing-induced fluid destratification and ullage condensation p 95 N87-21146
MOBILITY
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13509-1] p 100 N87-29116
MODAL RESPONSE
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32128
Validation of large space structures by ground tests
p 11 A87-32339
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0850] p 17 A87-33712
Modal analysis of dynamics of a deformable multibody spacecraft - The Space Station: A continuum approach
[AIAA PAPER 87-0925] p 17 A87-33727
The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0691] p 58 A87-28644
A laboratory simulation of flexible spacecraft control
[AIAA PAPER 87-2325] p 24 A87-50446
Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50508
Practical issues in computation of optimal, distributed control of flexible structures
[AIAA PAPER 87-2481] p 2[illegible] A87-50507
Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363
Structural dynamics system model reduction
p 32 N87-22727
MODEL REFERENCE ADAPTIVE CONTROL
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
Model reference adaptive control for large structural systems p 63 A87-50873
MODELS
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 83 A87-50187
Modeling of joints for the dynamic analysis of truss structures
[NASA-TP-2661] p 28 N87-20567
The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary
[NASA-CR-178276] p 8 N87-21020
Modeling and control of flexible structures
[AD-A177106] p 29 N87-21388
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet
[NASA-TM-89854] p 96 N87-21237
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 98 N87-25621
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 36 N87-25808
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183802] p 11 N87-28883
MODULATION
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A178815] p 140 N87-21024
MODULES
Conceptual design and integration of a Space Station resistojet propulsion assembly
[AIAA PAPER 87-1860] p 91 A87-45258
Conceptual design and integration of a space station resistojet propulsion assembly
[NASA-TM-88847] p 93 N87-20378
Fiber optics common transceiver module
p 117 N87-29180
MOLECULAR CLOUDS
High energy gamma ray astronomy
p 129 N87-24258
MOLECULAR COLLISIONS
External contamination environment of Space Station Customer Servicing Facility
[AIAA PAPER 87-1623] p 52 A87-43122
MOMENTS OF INERTIA
Adaptive momentum management for large space structures
[NASA-CR-178088] p 67 N87-22758
An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A179235] p 68 N87-23681
MOMENTUM
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42917
Adaptive momentum management for large space structures
[NASA-CR-178088] p 67 N87-22758
MOMENTUM TRANSFER
Optimal shuttle altitude changes using tethers
[AD-A178800] p 129 N87-22763
Distributed control using linear momentum exchange devices
[NASA-TM-100008] p 70 N87-24521
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-89084] p 70 N87-24723
MONTE CARLO METHOD
Localization in disordered periodic structures
[AIAA PAPER 87-0819] p 19 A87-33757
MOTION SICKNESS
Space motion sickness status report
[SAE PAPER 860923] p 163 A87-38714
An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A179235] p 68 N87-23681
MOTION SIMULATION
High speed simulation of multi-flexible-body systems with large rotations
[AIAA PAPER 87-0830] p 57 A87-33730
On the inadequacies of current multi-flexible body simulation codes
[AIAA PAPER 87-2248] p 7 A87-50412
Contact dynamics math model
[NASA-CR-179147] p 71 N87-26801
MOTORS
Common drive unit p 104 N87-29888
MOUNTING
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42917
MULTIBEAM ANTENNAS
Thermal deformation and electrical degradation of antenna reflector with truss backstructure
p 12 A87-32405
Multiple beam phased array for Space Station Control Zone Communications p 85 A87-45319
On-board K- and S-band multi-beam antennas
p 86 A87-46281
MULTIPATH TRANSMISSION
The effect of multipath on digital communications systems: With application to space station
[AD-A178578] p 88 N87-22878
MULTIPLE ACCESS
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31482
Multiple beam phased array for Space Station Control Zone Communications p 85 A87-45319
Antenna systems and RF coverage for the Space Station p 7 A8[illegible]525
Space Station multiple access communications system p 86 A87-46524
MULTIPLEXING
Fiber optics wavelength division multiplexing(components) p 117 N87-29181
MULTISPECTRAL BAND SCANNERS
The Reduced Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-973/86] p 130 N87-25408
MUSCULAR STRENGTH
Space suit reach and strength envelope considerations
[SAE PAPER 860950] p 48 A87-38737

N

NASA PROGRAMS
Flunking on Space Station cooperation?
p 150 A87-37694
The Space Station overview p 165 A87-41571
USA-Europe coordination and cooperation activities: Announcements of Opportunity -- polar platforms
p 170 N87-20832
Space operations: NASA's use of information technology. Report to the Chairman, Committee on Science, Space and Technology
[GAO/IMTEC-87-20] p 137 N87-22591
Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-75-418] p 171 N87-22599
National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240
National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-25594
National Aeronautics and Space Administration
p 172 N87-26620
NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988
[GPO-75-846] p 172 N87-26621
NASA SPACE PROGRAMS
Space research - At a crossroads
p 169 A87-32017
NASA's space program - Space Station: A status report and a view of its value for space science
p 1 A87-32277
The Space Station - Work Package 3
p 115 A87-32529
National space transportation studies
[SAE PAPER 861001] p 160 A87-32599
Manned space flight -- comparisons between U.S. and U.S.S.R. programs p 167 A87-33619

Overview of the NASA automation and robotics research program p 130 A87-23667
International cooperation in space
p 149 A87-34584
Innovations in space management: Macromanagement and the NASA heritage p 167 A87-34570
A crisis in the NASA space and earth sciences programme p 112 A87-27959
Concepts for the evolution of the Space Station Program
[SAE PAPER 860973] p 120 A87-38754
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860984] p 51 A87-38771
Reconstituting the US space programme
p 168 A87-41218
Priorities and policy analysis - A response to Alex Roland p 163 A87-41222
Mir - A second Sputnik? p 152 A87-46673
We shouldn't build the Space Station now
p 169 A87-46675
The Space Station: A personal journey --- Book
p 169 A87-46675
Scientific customer needs - NASA user
[AIAA PAPER 87-2180] p 118 A87-49582
Space Station - All change? p 154 A87-50792
Leadership in space transportation
p 170 A87-52889
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-006457] p 171 N87-23667
Control engineering tasks in the framework of the Columbus program
[MBB-[illegible]-E-9-3/86] p 156 N87-25942
Data management system architecture options for space stations --- Columbus project
[DES/DNP/TR/002/86] p 115 N87-26685
Study of data management system architecture options for space station --- Columbus project
[MATRA-RF/176/0003-4/IS-1] p 115 N87-26526
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 8 N87-21803
NASTRAN
Equivalent beam modeling using numerical reduction techniques p 21 N87-[illegible]
NAVSTAR SATELLITES
Electric propulsion for orbit transfer - A NAVSTAR case study (Has electric propulsion's time come?)
[AIAA PAPER 87-0985] p 88 A87-38431
NEAR FIELDS
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21667
NETWORK CONTROL
Network reliability p 117 N87-29157
NEUTRAL ATOMS
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 131 N87-29180
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-29181
NEUTRAL BEAMS
Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-55624
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-29181
Ground-based studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 169 N87-29200
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-29204
NEUTRAL BUOYANCY SIMULATION
Space Station EVA simulation demonstrates orbital assembly p 132 A87-32668
NEUTRALIZERS
An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-29688
NEUTRON STARS
High energy gamma ray astronomy
p 129 N87-24250
NICKEL HYDROGEN BATTERIES
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell
[NASA-TM-102102] p 79 N87-24802
Regenerative fuel cells for space applications
p 84 N87-29888
NOAA SATELLITES
Operational instruments on the Space Station-Polar Platforms - Contributions by NOAA and the international community p 127 A87-53140
NOISE
Guidelines for noise and vibration levels for the space station
[NASA-CR-178310] p 120 N87-24152
NONEQUILIBRIUM RADIATION
Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 135 A87-43090
NONLINEAR PROGRAMMING
A hybrid nonlinear programming method for design optimization p 7 A87-35716
NONLINEAR SYSTEMS
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33739
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures
p 21 A87-45575
Robust nonlinear attitude control of flexible spacecraft
p 60 A87-46273
Variable structure control system maneuvering of spacecraft p 64 N87-21889
Dynamics of trusses having nonlinear joints
p 32 N87-22724
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180458] p 71 N87-23252
Response of joint dominated space structures
[NASA-CR-180564] p 36 N87-26071
Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180633] p 37 N87-26096
Response of joint dominated space structures
[NASA-CR-181202] p 37 N87-26097
The effect of nonlinearities on flexible structures
[AD-A181738] p 39 N87-27259
NONLINEARITY
Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 29 N87-20349
Dynamic finite element modeling of flexible structures
[AD-A177165] p 30 N87-22252
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-89094] p 70 N87-24723
NONUNIFORM PLASMAS
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A176815] p 140 N87-21024
NOZZLE DESIGN
Evaluation of carbon-carbon for space engine nozzle
p 89 N87-28116
NOZZLE FLOW
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 92 A87-52252
NOZZLE GEOMETRY
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 92 A87-52252
NUCLEAR ELECTRIC POWER GENERATION
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1192] p 76 A87-41145
NUCLEAR ELECTRIC PROPULSION
ERATO orbital transfer vehicle with electronuclear power Study of the associated electronuclear generator
p 75 A87-36944
Performance of an SP-100/pulsed electrothermal thruster orbit transfer vehicle
[AIAA PAPER 87-2027] p 77 A87-45383
NUCLEAR ENGINES FOR ROCKET VEHICLES
NERVA derived nuclear orbit transfer system
[AIAA PAPER 87-2139] p 92 A87-45439
NUCLEAR POWER PLANTS
Telerobotic technology for nuclear and space applications
[NASA-CR-180923] p 102 N87-22342
NUCLEAR POWER REACTORS
Coaxial tube array space transmission line characterization
[NASA-TM-88964] p 80 N87-22002
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88585] p 79 N87-25583
NUCLEAR POWERED SHIPS
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements
[SAE PAPER 860943] p 45 A87-38733
NUCLEAR PROPULSION
Advanced propulsion activities in the USA
p 90 A87-41675
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 90 N87-25435
NUCLEAR REACTORS
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 90 N87-25435
NUMERICAL ANALYSIS
Thermal and dynamical effects on electrodynamic space tethers
[AD-A180276] p 130 N87-25251
NUMERICAL CONTROL
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1858] p 91 A87-45255
Robotic telepresence p 103 A87-46704
NUMERICAL FLOW VISUALIZATION
Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 135 A87-43090
NUMERICAL STABILITY
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739
NUTATION DAMPERS
Variable structure controller design for spacecraft nutation damping p 58 A87-38958
NUTRITION
Foods and nutrition in space
[SAE PAPER 861024] p 47 A87-38716

O

OCEAN DATA ACQUISITIONS SYSTEMS
Ocean-ice panel report --- International Space Station
p 156 N87-20835
OCEAN SURFACE
An advanced wind scatterometer for the Columbus Polar Platform payload p 155 A87-53117
OCEANOGRAPHIC PARAMETERS
Computer simulation of a rotational single-element flexible spacecraft boom
[AD-A181760] p 103 N87-26888
ODORS
Vapor fragrancer
[NASA-CASE-LAR-13680-1] p 166 N87-25881
OILS
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-25373
ON-LINE SYSTEMS
On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2458] p 61 A87-50506
ONBOARD DATA PROCESSING
On board Data Management p 112 A87-40591
Data management system architecture options for space stations --- Columbus project
[DES/DNP/TR/002/86] p 115 N87-26685
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89096] p 116 N87-29124
KSC Space Station Operations Language (SSOL)
p 138 N87-29169
ONBOARD EQUIPMENT
Space Station data management system architecture
p 111 A87-37293
OPERATING COSTS
Space Station EVA systems trade-off model
[SAE PAPER 860980] p 134 A87-38767
A model for the estimation of the operations and utilization costs of an international space station
p 168 A87-42267
OPERATING SYSTEMS (COMPUTERS)
TAE Plus: A conceptual view of TAE in the space station era p 9 N87-23157
SOT: A rapid prototype using TAE windows
p 114 N87-23161
Distributed computer taxonomy based on O/S structure p 116 N87-29127
SS focused technology: Gateways and NOS's
p 117 N87-29156
Network operating system p 117 N87-29166
Network operating system focus technology
p 117 N87-29167
KSC Space Station Operations Language (SSOL)
p 139 N87-29169
OPERATIONS RESEARCH
A multiple attribute decision analysis of manned attack systems
[AD-A178941] p 137 N87-2[illegible]
Optimization of payload mass placement in a dual keel space station
[NASA-TM-89081] p 60 N87-2[illegible]
Space Station and effector strategy study
[NASA-TM-100465] p 106 N87-29880
OPTICAL COMMUNICATION
Proof that timing requirements of the FDDI token ring protocol are satisfied --- fiber distributed data interface
p 112 A87-42821

OPTICAL DATA STORAGE MATERIALS
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443

OPTICAL MEASURING INSTRUMENTS
Measuring thermal expansion in large composite structures — for spaceborne telescopes
p 20 A87-38612

OPTICAL TRACKING
Optical correlator use at Johnson Space Center
p 59 A87-42855

OPTICS
Optical arrays for future astronomical telescopes in space p 126 A87-44533

OPTIMAL CONTROL
Robust controller design using frequency domain constraints p 11 A87-32229
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33610
Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0826] p 14 A87-33613
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0958] p 18 A87-33751
Gradient-based combined structural and control optimization p 21 A87-40886
Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2567] p 90 A87-49817
Reduced-order compensation - LQG reduction versus optimal projection
[AIAA PAPER 87-2388] p 61 A87-50472
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502
Practical issues in computation of optimal, distributed control of flexible structures
[AIAA PAPER 87-2461] p 25 A87-50507
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2484] p 93 A87-50509
A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system
[AIAA PAPER 87-2487] p 77 A87-50511
Dynamic modeling and optimal control design for large flexible space structures p 28 N87-20358
OPUS: Optimal Projection for Uncertain Systems
[AD-A178620] p 29 N87-21025
A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181085] p 34 N87-23680
Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26038
An investigation of methodology for the control and failure identification of flexible structures
p 39 N87-26821
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712
Optimal nodal transfer and aeroassisted transfer by aerocruise p 139 N87-28577
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183332] p 11 N87-29480
Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-29895

OPTIMIZATION
ASTROS - A multidisciplinary automated structural design tool
[AIAA PAPER 87-0713] p 6 A87-33557
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 6 A87-33560
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 56 A87-33573
Robustness optimization of structural and controller parameters
[AIAA PAPER 87-0781] p 14 A87-33591
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33611
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33755
Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34208
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46793
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20586
Equivalent beam modeling using numerical reduction techniques p 32 N87-22725
An integrated, optimization-based approach to the design and control of large space structures
[AD-A179458] p 34 N87-23683
Shape design sensitivity analysis and optimal design of structural systems
[NASA-CR-181085] p 37 N87-25370
Optimizing experimental programs in operational planning of research carried out from spacecraft
p 160 N87-29553

ORBIT PERTURBATION
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32815
Dynamic and thermal effects in very large space structures p 25 N87-20347

ORBIT TRANSFER VEHICLES
A two-dimensional numerical heat transfer model for a solar propulsion system p 74 A87-32306
System and operation analyses of OTV Network - A new space transportation concept p 145 A87-32475
Commercial US transfer vehicle overview
[SAE PAPER 861784] p 1 A87-32625
ERATO orbital transfer vehicle with electronuclear power Study of the associated electronuclear generator
p 75 A87-35244
Electric propulsion for orbit transfer - A NAVSTAR case study (Has electric propulsion's time come?)
[AIAA PAPER 87-0985] p 88 A87-38001
Geosynchronous earth orbit base propulsion - Electric propulsion options
[AIAA PAPER 87-0990] p 89 A87-38004
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145
Concepts for space maintenance of OTV engines
p 135 A87-41161
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1489] p 90 A87-43027
Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1505] p 160 A87-43031
Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 135 A87-43060
Space-based OTV bulkoff disposition
[AIAA PAPER 87-1787] p 91 A87-45181
Ariane transfer vehicle (ATV) to supply Space Station
[AIAA PAPER 87-1882] p 152 A87-45257
Liquid propulsion technology for expendable and STS launch vehicle transfer stages
[AIAA PAPER 87-1934] p 92 A87-45311
Performance of an SP-100/pulsed electrothermal thruster orbit transfer vehicle
[AIAA PAPER 87-2027] p 77 A87-45383
Concepts for space maintenance of OTV engines
p 139 A87-46000
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[AIAA PAPER 87-1764] p 92 A87-48572
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49815
Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2567] p 90 A87-49817
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2568] p 139 A87-49818
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 95 A87-52947
Aero-Assisted Orbital Transfer Vehicle (AOTV)
p 3 N87-20002
Orbital transfer vehicle concept definition and system analysis study. Volume 1A: Executive summary, Phase 2
[NASA-CR-178985] p 161 N87-21010
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[NASA-TM-88921] p 95 N87-22940
System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5). Volume 1A, part 1: Executive summary, phase 1
[NASA-CR-179139] p 97 N87-26062
System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2
[NASA-CR-179140] p 3 N87-26063
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 2: Cost estimates and work breakdown structure/dictionary, phase 1 and 2
[NASA-CR-179144] p 3 N87-26064
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results
[NASA-CR-179141] p 4 N87-26066
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results
[NASA-CR-179142] p 4 N87-26067
Design and demonstrate the performance of cryogenic components representative of space vehicles: Start basket liquid acquisition device performance analysis
[NASA-CR-179138] p 97 N87-26081
Concepts for space maintenance of OTV engines
p 137 N87-26097
Evaluation of carbon-carbon for space engine nozzle
p 98 N87-26116

ORBITAL ASSEMBLY
Space Station EVA simulation demonstrates orbital assembly p 132 A87-32006
Transient dynamics of orbiting flexible structural members p 54 A87-32338
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32729
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-34467
On-orbit assembly and repair p 135 A87-40376
Design, construction, and utilization of a space station assembled from 5-meter erectable struts
p 34 N87-24501
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532
Bi-stem gripping apparatus
[NASA-CASE-MFS-28185-1] p 107 N87-25586
Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89055] p 37 N87-26765

ORBITAL ELEMENTS
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49815

ORBITAL MANEUVERING VEHICLES
Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms
[AAS PAPER 86-041] p 133 A87-32743
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179103] p 161 N87-23877
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 100 N87-29118

ORBITAL MANEUVERS
Computer simulation of on-orbit manned maneuvering unit operations
[SAE PAPER 861783] p 47 A87-32632
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295
Conceptual design and integration of a Space Station resistojet propulsion assembly
[AIAA PAPER 87-1860] p 91 A87-45250
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49815
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2568] p 139 A87-49818
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2484] p 93 A87-50509
Conceptual design and integration of a space station resistojet propulsion assembly
[NASA-TM-88847] p 93 N87-20379
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734
Slew maneuvers on the SCOLE Laboratory Facility
p 69 N87-24011
Research in slewing and tracking control
p 70 N87-24512
Singular perturbation analysis of AOTV related trajectory optimization problems
[NASA-CR-180501] p 137 N87-26027
Optimal nodal transfer and aeroassisted transfer by aerocruise p 139 N87-28577

ORBITAL MECHANICS

Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms [AAS PAPER 86-041] p 133 A87-32743

Critical length for stable elongated orbiting structures p 148 A87-32819

The orbit configuration panel report — Columbus polar platforms p 157 N87-20640

Solar array flight dynamic experiment p 78 N87-22722

Adaptive momentum management for large space structures [NASA-CR-179085] p 67 N87-22758

An analysis of space station motion subject to the parametric excitation of periodic elevator motion [AD-A179235] p 68 N87-23681

Proceedings of the Second International Symposium on Spacecraft Flight Dynamics [ESA-SP-255] p 171 N87-25354

ORBITAL RENDEZVOUS

Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2 [LP-RP-AI-204-VOL-2] p 68 N87-24490

Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3 [LP-RP-AI-204-VOL-3] p 69 N87-24491

Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Docking-undocking phase analysis [LP-RP-AI-204-VOL-1] p 70 N87-24514

ORBITAL SERVICING

Space Station integration and verification concepts p 84 A87-31481

An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534

On-orbit fluid management p 132 A87-32543

Satellite servicing logistics [SAE PAPER 861723] p 132 A87-32812

Hubble Space Telescope satellite servicing [SAE PAPER 861796] p 133 A87-32844

Refueling satellites in space - The OSCRS program [SAE PAPER 861797] p 88 A87-32845

Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms [AAS PAPER 86-041] p 133 A87-32743

Planning for unanticipated satellite servicing teleoperations p 118 A87-33048

Transferring superfluid helium in space p 88 A87-34712

The SERVICE concept p 134 A87-36352

Demands imposed on a surface tension propellant tank due to refuelability in the microgravity environment of outer space [DGLR PAPER 86-104] p 88 A87-36756

A maintenance work station for Space Station [SAE PAPER 860933] p 167 A87-38723

The development of an EVA Universal Work Station [SAE PAPER 860952] p 164 A87-38739

Servicing of user payload equipment in the Space Station pressurized environment [SAE PAPER 860973] p 134 A87-38756

Advanced orbital servicing capabilities development [SAE PAPER 860982] p 134 A87-38769

On-orbit assembly and repair p 135 A87-40376

An integrated approach to spacecraft design for robotic servicing [AIAA PAPER 87-1672] p 100 A87-41152

The Canadian Robotic System for the Space Station [AIAA PAPER 87-1677] p 100 A87-41153

Modeling of fluid transfer in orbit [AIAA PAPER 87-1763] p 90 A87-45190

Operation of the orbital spacecraft consumables resupply system (OSCRS) at the Space Station [AIAA PAPER 87-1769] p 135 A87-45192

Ariane transfer vehicle (ATV) to supply Space Station [AIAA PAPER 87-1882] p 152 A87-45257

Mixing-induced ullage condensation and fluid destratification [AIAA PAPER 87-2018] p 92 A87-45357

Concepts for space maintenance of OTV engines p 136 A87-48050

The mission function control for deployment and retrieval of subsatellite [AIAA PAPER 87-2328] p 126 A87-50447

Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-23011

Satellite servicing mission preliminary cost estimation model [NASA-CR-171978] p 138 N87-20635

Servicing of the polar platform — Columbus space station p 138 N87-20639

Panel report on the polar platform servicing approach and its implications — Columbus space station p 138 N87-20641

Human factors in space station architecture 2. EVA access facility: A comparative analysis of 4 concepts for on-orbit space suit servicing [NASA-TM-86856] p 52 N87-24064

End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC) — in-orbiting servicing [FOK-TR-R-86-091-VOL-2] p 102 N87-24486

End effector development study, volume 1 — in-orbit servicing [FOK-TR-R-86-091-VOL-1] p 102 N87-25336

End effector development study. Volume 3: Appendices — in-orbit servicing [FOK-TR-R-86-091-VOL-3] p 102 N87-25337

Quick-disconnect inflatable seal assembly [NASA-CASE-KSC-11368-1] p 102 N87-25583

An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-25886

A study of fluid transfer management in space [FTMS-RPT-006] p 97 N87-26058

Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE) [ESA-CR(P)-2347] p 103 N87-28260

Mobile remote manipulator vehicle system [NASA-CASE-LAR-13393-1] p 103 N87-29118

Development of a standard connector for orbital replacement units for serviceable spacecraft p 40 N87-29864

Telerobotic work system: Concept development and evolution p 104 N87-29866

ORBITAL SPACE STATIONS

Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity [AD-A178687] p 120 N87-22762

Military man in space: A history of Air Force efforts to find a manned space mission [AD-A178873] p 171 N87-25815

ORBITAL SPACE TESTS

Evaluation testing of a mechanical actuator component operating in a simulated space environment p 160 A87-32549

Space station: A program overview p 171 N87-24488

The evolution of a serviceable EURECA [MBB-UR-E-823/86] p 121 N87-26841

ORGANIC COMPOUNDS

Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-29179

ORGANIC MATERIALS

Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules p 108 N87-29182

OSCILLATION DAMPERS

Response bounds for linear underdamped systems [ASME PAPER 87-APM-34] p 59 A87-42505

OTS (ESA)

Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32346

OXIDATION

Martin Marietta atomic oxygen beam facility p 139 A87-38622

A high flux pulsed source of energetic atomic oxygen — for spacecraft materials ground testing p 139 A87-38623

Supercritical water oxidation - Concept analysis for evolutionary Space Station application [SAE PAPER 860993] p 51 A87-38770

Oxidation protection coatings for polymers [NASA-CASE-LEW-14072-3] p 107 N87-23738

Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-29179

Product energy distributions and energy partitioning in O atom reactions on surfaces p 108 N87-29180

Chemical interactions in Low Earth Orbit (LEO) p 109 N87-29196

Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment [AD-A182931] p 110 N87-29709

OXIDATION RESISTANCE

An evaluation of candidate oxidation resistant materials for space applications in LEO [NASA-TM-100122] p 107 N87-25460

An evaluation of candidate oxidation resistant materials p 110 N87-29203

OXIDE FILMS

Oxidation protection coatings for polymers [NASA-CASE-LEW-14072-3] p 107 N87-23738

OXIDES

Surface modification to minimize the electrostatic charging of Kapton in the space environment p 87 N87-28090

OXYGEN

The Vanderbilt University neutral O-beam facility p 105 A87-32059

Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation [SAE PAPER 860927] p 163 A87-38717

Hydrogen-oxygen thruster with no products of combustion in exhaust plume [AIAA PAPER 87-1775] p 91 A87-45196

Hydrogen/oxygen economy for the space station p 98 N87-26130

Oxygen interaction with space-power materials [NASA-CR-181396] p 132 N87-29633

OXYGEN ATOMS

High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 105 A87-32060

Selected materials issues associated with Space Station p 105 A87-32061

Martin Marietta atomic oxygen beam facility p 139 A87-38622

A high flux pulsed source of energetic atomic oxygen — for spacecraft materials ground testing p 139 A87-38623

Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-38624

Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38625

Structure-property relationships in polymer resistance to atomic oxygen p 108 A87-38642

Variable energy, high flux, ground-state atomic oxygen source [NASA-CASE-NPO-16640-1-CU] p 8 N87-21881

Proceedings of the NASA Workshop on Atomic Oxygen Effects — low earth orbital environment [NASA-CR-181163] p 141 N87-29173

Review of Low Earth Orbital (LEO) flight experiments p 131 N87-29174

Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements p 108 N87-29175

Mass spectrometers and atomic oxygen p 141 N87-29176

Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment p 108 N87-29177

O-atom degradation mechanisms of materials p 141 N87-29178

Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-29179

Product energy distributions and energy partitioning in O atom reactions on surfaces p 108 N87-29180

The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-29181

Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules p 108 N87-29182

Dynamics of atom-surface interactions p 141 N87-29183

Laboratory studies of atomic oxygen reactions with solids p 4 N87-29185

High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-29186

Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation p 131 N87-29188

Pulsed source of energetic atomic oxygen p 108 N87-29189

Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-29190

The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-29191

An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets p 46 N87-29192

Reactions of atomic oxygen (O(3P)) with polybutadienes and related polymers p 109 N87-29197

Ground-based studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams p 109 N87-29200

Potential surfaces for O atom-polymer reactions p 109 N87-29201

NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-29202

An evaluation of candidate oxidation resistant materials p 110 N87-29203

Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-29204

Spacecraft ram glow and surface temperature p 10 N87-29205

Comments on the interaction of materials with atomic oxygen p 110 N87-29206

Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-29207

OXYGEN PRODUCTION

Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455

Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station p 46 A87-32544

Space Station life support oxygen generation by SPE water electrolyzer systems [SAE PAPER 860949] p 49 A87-38736

OXYGEN RECOMBINATION

Spacecraft ram glow and surface temperature p 10 N87-26205

OXYGEN SUPPLY EQUIPMENT

Complex system monitoring and fault diagnosis using communicating expert systems p 119 A87-40363

P

PACKETS (COMMUNICATION)

User data management p 4 N87-29163

PAINTS

An evaluation of candidate oxidation resistant materials p 110 N87-26203

PANELS

Slewing control experiment for a flexible panel p 78 N87-22740

A new approach for vibration control in large space structures p 33 N87-22743

PARABOLIC ANTENNAS

Near-field testing of the 5-meter model of the tetrahedral truss antenna [NASA-CR-178147] p 30 N87-21987

PARALLEL COMPUTERS

A Lanczos eigenvalue method on a parallel computer — for large complex space structure free vibration analysis [AIAA PAPER 87-0725] p 13 A87-33585

Experiences with the Lanczos method on a parallel computer p 21 A87-41159

PARALLEL PROCESSING (COMPUTERS)

Maximum likelihood identification using an array processor p 5 A87-32121

Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures — spacecraft masts [NASA-CR-180317] p 38 N87-27280

Proceedings: Computer Science and Data Systems Technical Symposium, volume 2 [NASA-TM-89288] p 116 N87-29144

PARAMETER IDENTIFICATION

An identification method for flexible structures [AIAA PAPER 87-0745] p 16 A87-33889

Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle [AIAA PAPER 87-1505] p 160 A87-43031

Single-mode projection filters for identification and state estimation of flexible structures [AIAA PAPER 87-2387] p 24 A87-50471

Adaptive identification of flexible structures by lattice filters [AIAA PAPER 87-2456] p 24 A87-50504

On-line identification and attitude control for SCOLE [AIAA PAPER 87-2459] p 61 A87-50505

Identification of large space structures - A factorization approach p 25 A87-52986

Mass property estimation for control of asymmetrical satellites p 63 A87-52988

A computer program for model verification of dynamic systems p 31 N87-22710

An overview of controls research on the NASA Langley Research Center grid p 66 N87-22720

Moving-bank multiple model adaptive estimation applied to flexible spacestructure control [AD-A178870] p 68 N87-22761

Application of physical parameter identification to finite-element models p 34 N87-24505

Maximum likelihood parameter identification of flexible spacecraft [ETN-87-80236] p 38 N87-27705

Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures [AD-A183302] p 11 N87-29880

A spline-based parameter and state estimation technique for static models of elastic surfaces [NASA-CR-180449] p 11 N87-30107

PARAMETERIZATION

Projection filters for modal parameter estimate for flexible structures [NASA-CR-180300] p 39 N87-28583

PARTIAL DIFFERENTIAL EQUATIONS

Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 26 N87-20348

PATHS

Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41615

PAYLOAD ASSIST MODULE

Commercial US transfer vehicle overview [SAE PAPER 861764] p 1 A87-32625

Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570

PAYLOAD CONTROL

Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540

Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms [AAS PAPER 86-041] p 133 A87-32743

Process control and data acquisition for commercial materials processing in space [AIAA PAPER 87-2197] p 113 A87-48583

Linear quadratic control system design for Space Station pointed payloads [AIAA PAPER 87-2530] p 161 A87-50532

PAYLOAD DELIVERY (STS)

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5). Volume 1A, part 1: Executive summary, phase 1 [NASA-CR-179139] p 97 N87-29062

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2 [NASA-CR-179140] p 3 N87-29063

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 3: Cost estimates and work breakdown structure/dictionary, phase 1 and 2 [NASA-CR-179144] p 3 N87-29064

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 2: Supporting research and technology report, phase 1 and 2 [NASA-CR-179143] p 3 N87-29065

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results [NASA-CR-179142] p 4 N87-29067

PAYLOAD DEPLOYMENT & RETRIEVAL SYSTEM

The mission function control for deployment and retrieval of subsatellite [AIAA PAPER 87-2326] p 126 A87-50447

PAYLOAD INTEGRATION

Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34208

Science and payload options for animal and plant research accommodations aboard the early Space Station [SAE PAPER 860953] p 164 A87-38740

PAYLOAD TRANSFER

The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29895

PAYLOADS

Space Station integration and verification concepts p 84 A87-31461

Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521

On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533

Servicing of user payload equipment in the Space Station pressurized environment [SAE PAPER 860873] p 134 A87-38756

From Eureca-A to Eureca-B p 155 A87-53916

Modal testing of the Olympus development model stowed solar array p 27 N87-20388

An astrometric facility for planetary detection on the space station [NASA-TM-89436] p 128 N87-20841

Botanical payloads for platforms and space stations [MBB-UR-E-921/86] p 158 N87-25340

Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583

PENETRATION

Space station integrated wall design and penetration damage control [NASA-CR-179165] p 38 N87-29581

Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics [NASA-CR-179166] p 39 N87-29582

Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system [NASA-CR-179167] p 4 N87-29583

PERFORMANCE PREDICTION

Thermal deformation and electrical degradation of antenna reflector with truss backstructure p 12 A87-32405

The Tethered Satellite System as a new remote sensing platform p 124 A87-39183

Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing [DGLR PAPER 86-122] p 101 A87-48156

Aerospatiale solar arrays, in orbit performance p 159 N87-29988

Computer simulation of deployment — solar arrays p 10 N87-29002

Test results from the solar array flight experiment p 83 N87-29010

PERFORMANCE TESTS

Evaluation of cryogenic system test options for the OTV on-orbit propellant depot [AIAA PAPER 87-1498] p 90 A87-43027

Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger [AIAA PAPER 87-1540] p 44 A87-44843

Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [AIAA PAPER 87-2120] p 93 A87-50197

Near-field testing of the 5-meter model of the tetrahedral truss antenna [NASA-CR-178147] p 30 N87-21987

A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet [NASA-TM-89854] p 96 N87-22237

Experimental characterization of deployable trusses and joints p 33 N87-22749

Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [NASA-TM-100113] p 96 N87-23821

PERMANENT MAGNETS

Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-39735

PERTURBATION

The effects of structural perturbations on decoupled control — spacecraft p 35 N87-25359

PERTURBATION THEORY

Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301

Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812

Equations of motion for maneuvering flexible spacecraft p 63 A87-52985

Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22726

Singular perturbation analysis of AOTV related trajectory optimization problems [NASA-CR-180301] p 137 N87-28927

PHASE CHANGE MATERIALS

A transient analysis of phase change energy storage system for solar dynamic power [AIAA PAPER 87-1489] p 77 A87-43004

The benefit of phase change thermal storage for spacecraft thermal management [AIAA PAPER 87-1482] p 43 A87-43014

PHASE SHIFT KEYING

Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel p 113 A87-45486

PHASE TRANSFORMATIONS

Phase change water recovery for Space Station - Parametric testing and analysis [SAE PAPER 860986] p 51 A87-38765

PHASED ARRAYS

Optical arrays for future astronomical telescopes in space p 128 A87-44533

Multiple beam phased array for Space Station Control Zone Communications p 86 A87-49519

PHOTOELECTRIC EMISSION

Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft [AD-A178815] p 140 N87-21024

PHOTOGRAMMETRY

Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370

PHOTOIONIZATION

Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-39324

PHOTOMASKS

Coded mask telescopes for X-ray astronomy p 123 A87-37786

PHOTONS

High energy gamma ray astronomy p 129 N87-24256

PHOTOVOLTAIC CELLS
Performance characteristics of a combination solar photovoltaic heat engine energy converter
[NASA-TM-89908] p 78 N87-23028
An overview of photovoltaic applications in space
p 80 N87-26414
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424
Advanced photovoltaic solar array design assessment
p 80 N87-26429
Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-26959
The space station power system p 81 N87-26960
Status of space station power system
p 84 N87-29915
PHOTOVOLTAIC CONVERSION
Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 79 N87-23695
Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696
An overview of photovoltaic applications in space
p 80 N87-26414
Space station power system p 80 N87-26447
High power/large area PV systems
p 80 N87-26452
Alternative power generation concepts for space
p 81 N87-26981
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits
p 159 N87-26988
PHYSIOLOGICAL EFFECTS
Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21698
PHYSIOLOGICAL FACTORS
Physiological requirements and pressure control of a spacecraft
[SAE PAPER 860965] p 150 A87-38747
Physiological aspects of EVA
[SAE PAPER 860981] p 164 A87-38768
PIEZOELECTRIC CERAMICS
Structural control by the use of piezoelectric active members p 69 N87-24509
An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-29857
PIEZOELECTRIC GAGES
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29717
Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-29898
PIEZOELECTRIC TRANSDUCERS
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0959] p 16 A87-33751
Structural control by the use of piezoelectric active members p 69 N87-24509
Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-26367
PIPELINING (COMPUTERS)
Maximum likelihood identification using an array processor p 5 A87-32121
PLANAR STRUCTURES
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures — spacecraft masts
[NASA-CR-180317] p 39 N87-27260
PLANETARY GEOLOGY
Experimentation in planetary geology
p 124 A87-40919
PLANETARY ORBITS
A survey of tether applications to planetary exploration
[AAS PAPER 86-208] p 123 A87-38689
PLANNING
Optimizing experimental programs in operational planning of research carried out from spacecraft
p 160 N87-29553
PLANTS (BOTANY)
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-38740
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-38757
A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications
[NASA-CR-177447] p 130 N87-25767
PLASMA ACCELERATORS
Micrometeorite exposure of solar arrays
p 82 N87-26992
PLASMA DENSITY
Theory of plasma contactors for electrodynamic tethered satellite systems p 85 A87-41609
PLASMA DYNAMICS
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23066
PLASMA ENGINES
CP/MPS - Contained plasma magnetic propulsion system: An advanced propulsion concept
[AIAA PAPER 87-1042] p 89 A87-38016
PLASMA EQUILIBRIUM
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182589] p 81 N87-28186
PLASMA GENERATORS
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-210] p 89 A87-38569
Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572
PLASMA INTERACTIONS
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32398
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180822] p 129 N87-22509
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23066
Electron beam experiments at high altitudes
p 142 N87-26946
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182589] p 81 N87-28186
PLASMA JETS
Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit
[NASA-TM-89118] p 66 N87-20339
PLASMA PROPULSION
CP/MPS - Contained plasma magnetic propulsion system: An advanced propulsion concept
[AIAA PAPER 87-1042] p 89 A87-38016
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-38628
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-38629
PLASMA SHEATHS
Theory of plasma contactors for electrodynamic tethered satellite systems p 85 A87-41609
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26937
PLASMAS (PHYSICS)
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180822] p 129 N87-22509
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-28591
PLASTIC COATINGS
Microcrack resistant structural composite tubes for space applications p 108 A87-41022
PLASTICS
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182031] p 110 N87-29709
PLUMES
External contamination environment of Space Station Customer Servicing Facility
[AIAA PAPER 87-1623] p 52 A87-43122
POINTING CONTROL SYSTEMS
Robust controller synthesis for a large flexible space antenna p 64 A87-32235
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32238
Precise pointing control of flexible spacecraft
p 56 A87-32446
Low-authority control through passive damping
[AAS PAPER 86-004] p 56 A87-32730
The Softmounted Inertially Reacting Pointing System (SIRPNT)
[AAS PAPER 86-007] p 56 A87-32732
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32738
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42817
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445
On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2459] p 61 A87-50505
Linear quadratic control system design for Space Station pointed payloads
[AIAA PAPER 87-2530] p 161 A87-50533
Large space structures ground experiment checkout
p 30 N87-22704
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721
Precision pointing and control of flexible spacecraft
p 66 N87-22723
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
Impact of space station appendage vibrations on the pointing performance of gimballed payloads
p 32 N87-22730
Vibration isolation for line of sight performance improvement p 67 N87-22742
Large spacecraft pointing and shape control
p 69 N87-24488
Control technology overview in CSI
p 69 N87-24507
Slew maneuvers on the SCOLE Laboratory Facility
p 69 N87-24511
SPOT/MEGS design and flight results obtained — solar array drive (MEGS) p 103 N87-29039
POLAR ORBITS
Design of a polar platform with an earth observation payload p 122 A87-32528
A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K.
p 125 A87-41430
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573
Earth resources instrumentation for the Space Station Polar Platform p 128 A87-44184
Conceptual design of the High-Resolution Imaging Spectrometer (HIRIS) for EOS p 128 A87-44185
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50582
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-265] p 128 N87-20821
Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group)
p 128 N87-20825
ESA Columbus polar platform design concept
p 159 N87-20827
Servicing of the polar platform — Columbus space station p 130 N87-20828
Orbit configurations — space station polar platform
p 159 N87-20829
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20830
USA-Europe coordination and cooperation activities: Announcements of Opportunity — polar platforms
p 170 N87-20832
Report of the atmosphere panel p 161 N87-20833
Land panel report — International Space Station
p 129 N87-20834
Ocean-ice panel report — International Space Station
p 159 N87-20835
Solid Earth panel report — Columbus program
p 157 N87-20836
Panel report on multidisciplinary instrumentation: New possibilities — Columbus space station
p 161 N87-20837
Panel report on new approaches to calibration and validation — Columbus polar platforms
p 157 N87-20838
Data management panel report — Columbus polar platforms p 114 N87-20839
The orbit configuration panel report — Columbus polar platforms p 157 N87-20840
Panel report on the polar platform servicing approach and its implications — Columbus space station
p 130 N87-20841
The Radarsat Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25006
Documentation for the SHADO particle wake routine
[AD-A181631] p 131 N87-28667
POLICIES
Space research - At a crossroads
p 168 A87-38017

Space Station program in a long-range space development scenario of Japan p 145 A87-32530

National space transportation studies
[SAE PAPER 861681] p 160 A87-32598

Priorities and policy analysis - A response to Alex Roland p 168 A87-41222

The Space Station: A personal journey -- Book
p 169 A87-46975

POLITICS

Reconstituting the US space programme
p 168 A87-41218

Leadership in space transportation
p 170 A87-53989

POLYBUTADIENE

Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-26197

POLYCRYSTALS

Frequency dispersion in the admittance of the polycrystalline Cu2S/CdS solar cell p 5 A87-29133

POLYESTER RESINS

Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182623] p 110 N87-27809

POLYETHER RESINS

PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44588

POLYETHYLENES

Potential surfaces for O atom-polymer reactions
p 109 N87-26201

POLYIMIDES

Oxidation protection coatings for polymers
[NASA-CASE-LEW-14072-3] p 107 N87-23736

Laboratory studies of atomic oxygen reactions with solids p 4 N87-26185

Surface modification to minimize the electrostatic charging of Kapton in the space environment
p 87 N87-26959

POLYMERIC FILMS

Structure-property relationships in polymer resistance to atomic oxygen p 108 A87-38842

Laboratory studies of atomic oxygen reactions with solids p 4 N87-26185

Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-26197

Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182931] p 110 N87-29709

POLYMERS

Oxidation protection coatings for polymers
[NASA-CASE-LEW-14072-3] p 107 N87-23736

Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 108 N87-26182

Potential surfaces for O atom-polymer reactions
p 109 N87-26201

Comments on the interaction of materials with atomic oxygen p 110 N87-26208

PORTABLE LIFE SUPPORT SYSTEMS

Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734

Evaluation of regenerative portable life support system options
[SAE PAPER 860948] p 49 A87-38735

POSITIVE FEEDBACK

Robust multivariable control of large space structures using positivity p 59 A87-47810

An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-28837

POSTLAUNCH REPORTS

SPOT solar array in-orbit deployment results evaluation p 63 N87-26868

POTABLE WATER

Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860986] p 50 A87-38764

Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27392

POWER CONDITIONING

New power processor interfaces MMS power module outputs -- Multimission Modular Spacecraft
p 77 A87-48264

Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-89888] p 68 N87-23680

POWER CONVERTERS

Space Station 20-kHz power management and distribution system p 75 A87-38913

Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2318] p 79 N87-24533

POWER FACTOR CONTROLLERS

Resistojet control and power for high frequency ac buses
[AIAA PAPER 87-0994] p 58 A87-41103

Resistojet control and power for high frequency ac buses
[NASA-TM-89860] p 63 N87-20477

Space station electrical power distribution analysis using a load flow approach p 80 N87-26699

POWER SUPPLY CIRCUITS

Power management equipment for space applications
[SAE PAPER 861521] p 74 A87-32578

POYNTING THEOREM

Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 26 N87-20348

PRECIPITATION (METEOROLOGY)

Observation of precipitation from space by the weather radar p 145 A87-32507

PREDICTION ANALYSIS TECHNIQUES

Experimental characterization of deployable trusses and joints p 33 N87-22749

Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-84/85] p 35 N87-24516

PREDICTIONS

Technology projections and space systems opportunities for the 2000-2030 time period
[AAS PAPER 86-109] p 2 A87-53086

Toward the year 2000: The near future of the American civilian and military space programs
[DE87-008487] p 171 N87-22887

PRESSURE PULSES

Dynamical responses to pulse excitations in large space structures
[AIAA PAPER 87-0710] p 15 A87-33658

PRESSURIZED CABINS

Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860873] p 134 A87-38755

Columbus pressurized modules p 153 A87-46945

The hardware/software architecture of the Columbus pressurized module element
[AIAA PAPER 87-2211] p 154 A87-48596

PRESSURIZING

Physiological requirements and pressure control of a spacecabins
[SAE PAPER 860985] p 150 A87-38747

PRESTRESSING

Preloadable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 161 N87-25582

PRIMARY BATTERIES

Advanced fuel cell concepts for future NASA missions
p 99 N87-29930

PROBLEM SOLVING

Experiences with the Lanczos method on a parallel computer p 21 A87-41159

Large space structures testing
[NASA-TM-100308] p 35 N87-24520

PROCESS CONTROL (INDUSTRY)

Process control and data acquisition for commercial materials processing in space
[AIAA PAPER 87-2187] p 113 A87-48583

PRODUCT DEVELOPMENT

A microgravity isolation mount p 161 N87-29881

PRODUCTION COSTS

Space Station EVA systems trade-off model
[SAE PAPER 860990] p 134 A87-38767

PROGNOZ SATELLITES

The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-38443

PROGRAM VERIFICATION (COMPUTERS)

Space station data management system - A common GSE test interface for systems testing and verification
p 112 A87-37294

PROGRAMMING LANGUAGES

KSC Space Station Operations Language (SSOL)
p 138 N87-29188

PROJECT MANAGEMENT

The Space Station - Work Package 3
p 118 A87-32529

USA-Europe coordination and cooperation activities: Announcements of Opportunity -- polar platforms
p 170 N87-20832

The Columbus program p 157 N87-25031

PROJECT PLANNING

Space station experiment definition: Long-term cryogenic fluid storage
[NASA-CR-4072] p 97 N87-24841

Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25560

PROJECTILES

A space debris simulation facility for spacecraft materials evaluation p 11 A87-32058

PROJECTION

Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2387] p 24 A87-50471

Reduced-order compensation - LQG reduction versus optimal projection
[AIAA PAPER 87-2388] p 61 A87-50472

PROPELLANT STORAGE

Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1498] p 90 A87-43027

PROPELLANT TANKS

Demands imposed on a surface tension propellant tank due to refuelability in the microgravity environment of outer space
[DGLR PAPER 86-104] p 88 A87-36756

Operation of the orbital spacecraft consumables resupply system (OSCRS) at the Space Station
[AIAA PAPER 87-1768] p 135 A87-45192

Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation
[AIAA PAPER 87-2021] p 92 A87-45360

Propellant tank resupply system
[AD-D012559] p 93 N87-20375

PROPELLANT TESTS

Space station propulsion test bed: A complete system
p 98 N87-26131

PROPELLANT TRANSFER

Transferring superfluid helium in space
p 88 A87-34712

Modeling of fluid transfer in orbit
[AIAA PAPER 87-1763] p 90 A87-45190

Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[AIAA PAPER 87-1764] p 92 A87-48572

Overview: Fluid acquisition and transfer
p 94 N87-21146

Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[NASA-TM-89921] p 96 N87-22946

An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-25888

A study of fluid transfer management in space
[FTMS-RPT-008] p 97 N87-26058

PROPELLANTS

Water-propellant resistojets for man-tended platforms
[NASA-TM-100110] p 98 N87-26126

PROPULSION SYSTEM CONFIGURATIONS

The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573

Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-162] p 90 A87-42880

Thermal design of a large spacecraft propulsion system
[AIAA PAPER 87-1860] p 44 A87-45258

Space station propulsion system technology
[NASA-TM-100108] p 97 N87-25422

Propulsion recommendations for space station free flying platforms p 98 N87-26129

Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

PROPULSION SYSTEM PERFORMANCE

Advanced propulsion activities in the USA
p 90 A87-41575

NERVA derived nuclear orbit transfer system
[AIAA PAPER 87-2155] p 92 A87-45439

Propulsion recommendations for space station free flying platforms p 98 N87-26129

A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132

Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

PROPULSIVE EFFICIENCY

Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145

Density uncertainty effect on cost of space station reboost p 170 N87-20867

PROTECTIVE CLOTHING

Space suit extravehicular hazards protection development
[NASA-TM-89088] p 53 N87-27407

PROTECTIVE COATINGS

Selected materials issues associated with Space Station p 106 A87-32081

Oxidation protection coatings for polymers
[NASA-CASE-LEW-14072-3] p 107 N87-23736

An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets
p 45 N87-26180

NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-26202
An evaluation of candidate oxidation resistant materials p 110 N87-26203
Surface modification to minimise the electrostatic charging of Kapton in the space environment
p 87 N87-26959

PROTOCOL (COMPUTERS)
Star topology spacecraft data bus
p 112 A87-37431
Advanced local area network concepts
p 117 N87-29153

PROTOTYPES
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532
User interface and payload command and control
p 73 N87-29162

PROVING
Panel report on new approaches to calibration and validation -- Columbus polar platforms
p 157 N87-20636

PROVISIONING
Space Station Food System
[SAE PAPER 860830] p 48 A87-38720

PSYCHOLOGICAL EFFECTS
Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21996

PSYCHOLOGICAL FACTORS
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180342] p 53 N87-27405

PULSARS
High energy gamma ray astronomy
p 129 N87-24258

PULSE COMMUNICATION
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31462
The effect of multipath on digital communications systems: With application to space station
[AD-A178578] p 88 N87-22876

PULSED RADIATION
Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26180

PULSES
Comparison of wave-mode coordinate and pulse summation methods
[AD-A177795] p 30 N87-21992

PURIFICATION
Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27392

Q

QUALIFICATIONS
Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A175529] p 26 N87-20355
Future trends in spacecraft design and qualification
p 2 N87-20356
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357
Qualification of the faint object camera
p 127 N87-20359
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 66 N87-20360
Structural qualification of large spacecraft
p 26 N87-20361
Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363
Low frequency vibration testing on satellites
p 27 N87-20364
Modal-survey testing for system identification and dynamic qualification of spacecraft structures
p 27 N87-20365

QUALITY CONTROL
Quality monitoring in two-phase heat transport systems for large spacecraft
[SAE PAPER 860958] p 42 A87-38743
EMC and power quality standards for 20-kHz power distribution
[NASA-TM-88925] p 76 N87-22004

QUANTUM CHEMISTRY
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 108 N87-26182
Potential surfaces for O atom-polymer reactions
p 109 N87-26201

QUANTUM EFFICIENCY
Oxygen interaction with space-power materials
[NASA-CR-181200] p 132 N87-26600

R

RADAR
Flight array processor p 116 N87-29148

RADAR ANTENNAS
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89295] p 79 N87-25836

RADARSAT
The Radarsat Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25506

RADIATION DAMAGE
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424

RADIATION DOSAGE
Radiation dose prediction for Space Station
[SAE PAPER 860924] p 139 A87-38715
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-48028

RADIATION EFFECTS
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181
Space stable thermal control coatings
[AD-A182796] p 110 N87-26584

RADIATION HAZARDS
The problem of radiation exposure in the Space Station
[DGLR PAPER 86-175] p 153 A87-48157
Radiation shielding requirements on long-duration space missions
[AD-A177512] p 140 N87-21881

RADIATION PRESSURE
Dynamic and thermal effects in very large space structures p 25 N87-20347

RADIATION PROTECTION
Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-48030
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26607

RADIATION SOURCES
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-46882

RADIATIVE HEAT TRANSFER
Radiation heat transfer calculations for space structures
[AIAA PAPER 87-1522] p 44 A87-44830

RADICALS
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 108 N87-26182

RADIO ASTRONOMY
Status of orbital astronomy projects
p 128 N87-21873

RADIO BEACONS
Design of a beacon receiving system for the Olympus satellite p 86 A87-50157

RADIOBIOLOGY
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-48029
Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-48030

RANDOM VIBRATION
Prediction of random vibrational responses of a large spacecraft in acoustic environment by BLFF method
p 144 A87-32334
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20509

RANKINE CYCLE
Organic Rankine cycle power conversion systems for space applications p 159 N87-26069

RANKING
High power/large area PV systems
p 80 N87-26452

RAYLEIGH-RITZ METHOD
Localization of vibrations in large space reflectors
[AIAA PAPER 87-0949] p 18 A87-33745

REACTION KINETICS
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements
p 103 N87-26175
Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-26179
Product energy distributions and energy partitioning in O atom reactions on surfaces p 108 N87-26180
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 108 N87-26182
Chemical interactions in Low Earth Orbit (LEO)
p 109 N87-26199

REACTION PRODUCTS
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 108 N87-26182

REACTION WHEELS
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel
p 55 A87-32448
Vibration isolation for line of sight performance improvement p 67 N87-22742

REAL TIME OPERATION
On the performance analysis of a real-time distributed computer system p 111 A87-31518
Real-time simulation for Space Station
p 7 A87-37298
Video image processing p 116 N87-29150

RECOMBINATION REACTIONS
Structure-property relationships in polymer resistance to atomic oxygen p 108 A87-38642

RECTANGULAR PANELS
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts
[NASA-CR-180317] p 38 N87-27280

RECYCLING
Gas and water recycling system for IOC vivarium experiments -- Initial Operational Capacity
p 48 A87-32457
Water recycling system using thermopervaporation method p 46 A87-32458
Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27392

REDUCED GRAVITY
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533
Symposium on Microgravity Fluid Mechanics, Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 p 89 A87-35785
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments
p 151 A87-36836
Liquid droplet radiator development status -- waste heat rejection devices for future space vehicles
[AIAA PAPER 87-1537] p 43 A87-43059
Columbus pressurized modules p 153 A87-48945
Microgravity experiments onboard Eureca
p 155 A87-53084
Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 136 N87-20308
Liquid droplet radiator development status
[NASA-TM-88852] p 44 N87-20353
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180089] p 29 N87-20589
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement
p 84 N87-21147
Numerical modelling of cryogenic propellant behavior in low-G p 85 N87-21148
Microgravity fluid management in two-phase thermal systems p 85 N87-21152
Microgravity fluid management requirements of advanced solar dynamic power systems
p 77 N87-21153
Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721
Ideas for educational physics experiments in space
p 130 N87-25089
Active vibration control in microgravity environment
p 72 N87-26700
The evolution of a serviceable EURECA
[MBB-UR-E-823/86] p 121 N87-26841
A microgravity isolation mount p 101 N87-29081

REDUCED ORDER FILTERS
Reduced-order compensation - LQG reduction versus optimal projection
[AIAA PAPER 87-2383] p 61 A87-50472

REDUCTION (CHEMISTRY)
An advanced carbon reactor subsystem for carbon dioxide reduction
[SAE PAPER 860995] p 51 A87-38772

REENTRY EFFECTS
Effect of long-term exposure to LEO space environment on spacecraft materials p 100 A87-39428

REENTRY PHYSICS
Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 135 A87-43060

REFERENCE SYSTEMS
Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 80 A87-50572

REFILLING
Propellant tank resupply system
[AD-D012559] p 93 N87-20375
REFLECTOR ANTENNAS
Thermal deformation and electrical degradation of antenna reflector with truss backstructure
p 12 A87-32405
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33611
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0869] p 15 A87-33633
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021
Robust control for large space antennas
p 67 N87-24499
Controls-structures-electromagnetics interaction program p 69 N87-24502
REFLECTORS
Localization of vibrations in large space reflectors
[AIAA PAPER 87-0949] p 18 A87-33745
Composite space antenna structures - Properties and environmental effects p 20 A87-36810
REFRIGERATORS
Magnetic refrigeration for space platforms
[SAE PAPER 861724] p 118 A87-32813
REFUELING
Refueling satellites in space - The OSCRS program
[SAE PAPER 861797] p 88 A87-32845
Demands imposed on a surface tension propellant tank due to refuelability in the microgravity environment of outer space
[DGLR PAPER 86-104] p 88 A87-36756
Propellant tank resupply system
[AD-D012559] p 93 N87-20375
Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11368-1] p 102 N87-25683
A study of fluid transfer management in space
[FTMS-RPT-008] p 97 N87-26058
REGENERATIVE FUEL CELLS
Development of an alkaline fuel cell subsystem
[NASA-CR-172002] p 81 N87-28188
Space Electrochemical Research and Technology (SERT)
[NASA-CP-2484] p 5 N87-29914
Advanced fuel cell concepts for future NASA missions
p 89 N87-29930
Regenerative fuel cells for space applications
p 84 N87-29928
RELEASING
Preloadable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 101 N87-25682
RELIABILITY
A multiple attribute decision analysis of manned airlock systems
[AD-A178841] p 137 N87-23882
Network reliability p 117 N87-29157
RELIABILITY ENGINEERING
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37683
REMOTE CONTROL
Traction-drive telerobot for space manipulation
[DE87-008288] p 102 N87-22233
Telerobotic work system: Concept development and evolution p 104 N87-29838
REMOTE HANDLING
A master-slave manipulator system for space use
p 147 A87-32548
The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 103 A87-41183
REMOTE MANIPULATOR SYSTEM
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547
Robots on the Space Station p 103 A87-40844
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570
Development of a small-sized space manipulator
p 101 A87-51979
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20570
Design, construction, and utilization of a space station assembled from 5-meter erectable struts
p 34 N87-24501
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-89091] p 137 N87-25880
Remote handling facility and equipment used for space truss assembly
[DE87-009121] p 100 N87-27408
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26280
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 103 N87-29118
The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29865
REMOTE SENSING
Design of a polar platform with an earth observation payload p 122 A87-32538
The Tethered Satellite System as a new remote sensing platform p 124 A87-39183
Space Station opportunity for UK in earth sensing
p 152 A87-41678
Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986
[SPIE-644] p 125 A87-44176
Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54188
SAFE/DAE: Modal test in space p 77 N87-20584
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-266] p 128 N87-20621
Remote sensing applications: Commercial issues and opportunities for space station -- SPOT
p 156 N87-20626
Land panel report -- International Space Station
p 128 N87-20634
Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-22457
Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817
REMOTE SENSORS
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20630
Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25680
Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-618/86] p 136 N87-26088
REMOTELY PILOTED VEHICLES
Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 89 A87-31483
RENDEZVOUS GUIDANCE
Rendezvous and docking tracker
[AAS PAPER 86-014] p 133 A87-32730
Laser docking system flight experiment
[AAS PAPER 86-043] p 89 A87-32745
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41615
REPLENISHMENT
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179108] p 161 N87-23877
REQUIREMENTS
High power/large area PV systems
p 80 N87-29452
Space Station end effector strategy study
[NASA-TM-100483] p 100 N87-29560
RESCUE OPERATIONS
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179108] p 161 N87-23877
RESEARCH AND DEVELOPMENT
Space research - At a crossroads
p 168 A87-33017
Design and development of a Space Station proximity operations research and development mockup
[SAE PAPER 861785] p 133 A87-38804
K.E. Tsiolkovskii and problems in the development of science and technology -- Russian book
p 151 A87-40342
Advanced technology for the Space Station
p 120 A87-40553
1987 status report - United States Air Force electric propulsion research and development
[AIAA PAPER 87-1099] p 80 A87-41122
Technical and Management Information System (TMIS)
[AIAA PAPER 87-2217] p 114 A87-48880
Development of a small-sized space manipulator
p 101 A87-51979
Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54188
National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-25024
RESEARCH FACILITIES
Telerobotic technology for nuclear and space applications
[NASA-CR-180823] p 102 N87-22242
RESIDUAL STRESS
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33709
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327
RESIN MATRIX COMPOSITES
PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44588
RESISTOJET ENGINES
Resistojet control and power for high frequency ac buses
[AIAA PAPER 87-0994] p 58 A87-41103
Conceptual design and integration of a Space Station resistojet propulsion assembly
[AIAA PAPER 87-1860] p 91 A87-45258
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 93 A87-50197
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 62 A87-52252
Conceptual design and integration of a space station resistojet propulsion assembly
[NASA-TM-88947] p 93 N87-20376
Resistojet control and power for high frequency ac buses
[NASA-TM-88980] p 63 N87-20477
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet
[NASA-TM-88954] p 98 N87-22237
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 96 N87-23821
Resistojet plume and induced environment analysis
[NASA-TM-88857] p 96 N87-24538
Space station propulsion system technology
[NASA-TM-100108] p 97 N87-25422
Water-propellant resistojets for man-tended platforms
[NASA-TM-100110] p 99 N87-28135
RESONANCE
Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88995] p 68 N87-23890
RESONANT FREQUENCIES
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533
Wave propagation in periodic truss structures
[AIAA PAPER 87-0944] p 18 A87-33742
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-48121
Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 9 N87-22716
RESONANT VIBRATION
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-48121
RETRACTABLE EQUIPMENT
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 62 N87-26873
The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-26012
REUSABLE LAUNCH VEHICLES
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573
REUSABLE SPACECRAFT
The SERVICE concept p 134 A87-38282
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860968] p 42 A87-38738
Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1505] p 160 A87-43081
REUSE
Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 53 A87-35762
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 62 N87-26873

RIGID STRUCTURES
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33564
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-46121
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50562
Variable structure control system maneuvering of spacecraft p 64 N87-21989
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts
[NASA-CR-180317] p 38 N87-27260
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 82 N87-29873
The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-29875
The Fokker Stronglback solar array p 82 N87-29879
The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-29012
RIT ENGINES
Status of the RITA - Experiment on EURECA -- Radio Frequency Ion Thruster Assembly
[AIAA PAPER 87-0988] p 123 A87-38002
ROBOTICS
A master-slave manipulator system for space use p 147 A87-32546
System architecture for the telerobotic work system
[AAS PAPER 86-044] p 99 A87-32748
Overview of the NASA automation and robotics research program p 100 A87-33667
Manned spacecraft automation and robotics p 100 A87-37300
Planning for space robotics developments and applications p 135 A87-40377
An integrated approach to spacecraft design for robotic servicing
[AIAA PAPER 87-1672] p 100 A87-41152
The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 100 A87-41153
Space: New opportunities for all people; Selected Proceedings of the Thirty-seventh International Astronautical Congress, Innsbruck, Austria, Oct. 4-11, 1986 p 166 A87-41588
Robotic telepresence p 100 A87-46704
Space Station autonomy - What are the challenges? How can they be met? p 101 A87-53059
The Oak Ridge National Laboratory's Robotics and Intelligent Systems Program
[DE87-004627] p 101 N87-20774
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26260
Space Station end effector strategy study
[NASA-TM-100488] p 103 N87-29580
The 21st Aerospace Mechanisms Symposium
[NASA-CP-2470] p 103 N87-29858
Development of a standard connector for orbital replacement units for serviceable spacecraft p 40 N87-29864
Telerobotic work system: Concept development and evolution p 104 N87-29868
Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-29887
ROBOTS
Robots on the Space Station p 100 A87-40944
Control of robot manipulator compliance p 100 A87-45797
The astronaut and the robot - Short- and long-term scenarios for space technology p 101 A87-53061
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004616] p 101 N87-22231
Traction-drive telerobot for space manipulation
[DE87-005389] p 102 N87-22233
Telerobotic technology for nuclear and space applications
[NASA-CR-180923] p 102 N87-22342
Self-calibration strategies for robot manipulators p 102 N87-29884
ROBUSTNESS (MATHEMATICS)
Robust controller design using frequency domain constraints p 11 A87-50259
Robust controller synthesis for a large flexible space antenna p 64 A87-50258
Integrated control/structure design and robustness
[SAE PAPER 861921] p 6 A87-50567
Robustness optimization of structural and controller parameters
[AIAA PAPER 87-0781] p 14 A87-33591
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
Robust eigensystem assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416
Robust control of a large space antenna
[AIAA PAPER 87-2253] p 66 A87-50417
Integrated control/structure design and robustness p 65 N87-22060
ROCKET ENGINE DESIGN
CP/MPS - Contained plasma magnetic propulsion system: An advanced propulsion concept
[AIAA PAPER 87-1042] p 59 A87-38016
Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-162] p 90 A87-42660
Thermal design of a large spacecraft propulsion system
[AIAA PAPER 87-1863] p 44 A87-45258
Concepts for space maintenance of OTV engines p 136 A87-48000
Structure and design of spacecraft -- Russian book p 155 A87-51670
ROCKET ENGINES
Optimal shuttle altitude changes using tethers
[AD-A179205] p 129 N87-22756
Concepts for space maintenance of OTV engines p 137 N87-26067
ROCKET EXHAUST
Resistojet plume and induced environment analysis
[NASA-TM-88857] p 96 N87-24536
ROCKET NOZZLES
Evaluation of carbon-carbon for space engine nozzle p 96 N87-26116
ROCKET PROPELLANTS
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 93 A87-50187
Overview: Fluid acquisition and transfer p 94 N87-21146
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet
[NASA-TM-88954] p 96 N87-22237
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 96 N87-23621
ROCKET TEST FACILITIES
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1850] p 91 A87-45256
Space station propulsion test bed: A complete system p 96 N87-26131
RODS
Critical length for stable elongated orbiting structures p 148 A87-32819
Dynamics of flexible structures performing large overall motions: A geometrically-nonlinear approach p 64 N87-21336
ROLLER BEARINGS
Space Station alpha joint bearing p 83 N87-29882
ROTATING BODIES
High speed simulation of multi-flexible-body systems with large rotations
[AIAA PAPER 87-0930] p 57 A87-33730
Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29869
ROTATING SHAFTS
Common drive unit p 104 N87-29880
ROTATION
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A183080] p 71 N87-29362
ROTOR BLADES (TURBOMACHINERY)
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 160 A87-29389

S

SAFETY
20 kHz Space Station power system p 76 A87-40979
The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary
[NASA-CR-178270] p 6 N87-21089
SAFETY FACTORS
Safety on the Space Station p 162 A87-30083
Automated Subsystem Control for Life Support System (ASCLSS)
[NASA-CR-172000] p 59 N87-29117
SAFETY MANAGEMENT
Fire safety concerns in space operations
[NASA-TM-89848] p 165 N87-29942
SALYUT SPACE STATION
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6 p 147 A87-32814
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735
USSR Report: Space
[JPRS-USP-86-004] p 158 N87-27687
Pravda commentary, photos of Mir orbital station p 158 N87-27689
Progress in theory, technology of space materials science p 158 N87-27695
SATELLITE ANTENNAS
Thermal deformation and electrical degradation of antenna reflector with truss backstructure p 12 A87-32405
Precise pointing control of flexible spacecraft p 55 A87-32446
Design considerations for a one-kilometer antenna stick
[AIAA PAPER 87-0871] p 15 A87-33636
On-board K- and S-band multi-beam antennas p 86 A87-48281
Design of a beacon receiving system for the Olympus satellite p 86 A87-50157
Summary of recent SAR instrument studies p 159 N87-27686
SATELLITE ATTITUDE CONTROL
A review of modelling techniques for the open and closed-loop dynamics of large space systems p 12 A87-32337
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32739
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment p 149 A87-34257
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
Comparison of different attitude control schemes for large communications satellites
[AIAA PAPER 87-2391] p 61 A87-50475
Global treatment of energy dissipation effects for multibody satellites p 62 A87-51010
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2
[LP-RP-AI-204-VOL-2] p 69 N87-24480
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24481
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Docking-undocking phase analysis
[LP-RP-AI-204-VOL-1] p 70 N87-24514
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25339
Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25350
SATELLITE COMMUNICATION
Communication missions for geostationary platforms p 84 A87-34707
Japan's space development programs for communications - An overview p 152 A87-42158
An advanced geostationary communications platform p 125 A87-42165
Japanese data relay satellite system
[AIAA PAPER 87-2150] p 154 A87-49590
SATELLITE CONTROL
Tethered satellite program control strategy
[AAS PAPER 86-231] p 129 A87-32379
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50002
SATELLITE DESIGN
Structural design and component tests of large geostationary satellite bus p 144 A87-32369
Development of fluid loop system for spacecraft p 144 A87-32370
Comparison of satellite support structure aluminum versus graphite epoxy
[SAWE PAPER 1692] p 20 A87-32279
Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 120 N87-20029
ESA Columbus polar platform design concept p 150 N87-20027

Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-29006

SATELLITE GROUND SUPPORT

Satellite servicing logistics
[SAE PAPER 861723] p 132 A87-32912

Space station data management system - A common GSE test interface for systems testing and verification
p 112 A87-37294

SATELLITE LIFETIME

Simulation of on-orbit satellite fragmentations
p 140 N87-24515

SATELLITE NETWORKS

Japanese space information system overview
[AIAA PAPER 87-2191] p 153 A87-48579

Japanese data relay satellite system
[AIAA PAPER 87-2189] p 154 A87-48565

SATELLITE OBSERVATION

Conceptual design of the High-Resolution Imaging Spectrometer (HIRIS) for EOS p 126 A87-44185

Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-22457

SATELLITE ORBITS

Orbital modifications using forced tether-length variations p 124 A87-40858

Optimal shuttle altitude changes using tethers
[AD-A179205] p 129 N87-22756

SATELLITE POWER TRANSMISSION (TO EARTH)

The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35799

SATELLITE SOLAR ENERGY CONVERSION

Solar power satellites — Russian book
p 152 A87-44883

Power plants in space p 155 A87-53880

SATELLITE SOLAR POWER STATIONS

Shape control of the directional pattern in a microwave-beam power transmission channel
p 148 A87-34345

The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35799

SATELLITE SURFACES

Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41811

SATELLITE TRANSMISSION

R&D department head on orbital power plants
p 158 N87-27693

SATELLITE-BORNE INSTRUMENTS

An advanced wind scatterometer for the Columbus Polar Platform payload p 156 A87-53117

Panel report on multidisciplinary instrumentation: New possibilities — Columbus space station
p 161 N87-20637

Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25660

Summary of recent SAR instrument studies
p 159 N87-27686

Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-519/86] p 138 N87-26603

SATELLITE-BORNE RADAR

Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88858] p 79 N87-25839

SATELLITE-TO-SATELLITE TRACKING

Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-519/86] p 138 N87-26603

SCALE MODELS

Considerations in the design and development of a space station scale model p 9 N87-22711

SCALING LAWS

The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 116 A87-33033

On-orbit cryogenic fluid management experimental data requirements using reference fluids
[AIAA PAPER 87-1869] p 80 A87-44032

Verification of large beam-type space structures
p 31 N87-22712

COFS 3 multibody dynamics and control technology
p 69 N87-24806

Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 39 N87-25686

SCATHA SATELLITE

Potential modulation on the SCATHA spacecraft
p 139 A87-34480

Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22936

SCATTEROMETERS

Observation of precipitation from space by the weather radar p 145 A87-32807

An advanced wind scatterometer for the Columbus Polar Platform payload p 156 A87-53117

Flight array processor p 116 N87-29148

SCHEDULING

Space Shuttle flight rates and utilization
p 1 A87-27983

Integrated scheduling and resource management — for Space Station Information System
[AIAA PAPER 87-2213] p 119 A87-48587

Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48602

A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system
[AIAA PAPER 87-2467] p 77 A87-50611

SCIENTIFIC SATELLITES

Space research - At a crossroads
p 166 A87-32017

The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450

Thick dielectric charging on high altitude spacecraft
p 87 N87-25661

SEALS (STOPPERS)

Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11368-1] p 102 N87-25583

SECURITY

Military space station implications
[AD-A180831] p 172 N87-26664

SELF CONSISTENT FIELDS

Potential surfaces for O atom-polymer reactions
p 109 N87-26201

SELF ORGANIZING SYSTEMS

Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41617

SEMICONDUCTOR DEVICES

On the control of structures by applied thermal gradients p 33 N87-22747

Space station power semiconductor package
[NASA-CR-180829] p 81 N87-26625

SEMICONDUCTORS (MATERIALS)

Testing of materials for solar power space applications p 107 A87-53946

SENSITIVITY

Sensitivity of distributed structures to model order in feedback control
[AIAA PAPER 87-0880] p 56 A87-33710

Shape design sensitivity analysis and optimal design of structural systems
[NASA-CR-181085] p 37 N87-26370

Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures
[NASA-CR-4089] p 40 N87-29889

SENSORS

Fiber-optic monitors for space structures
p 11 A87-31935

Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33755

SERVICE LIFE

An overview of photovoltaic applications in space
p 80 N87-29414

Stopping differential charging of solar arrays
p 83 N87-29884

An electromechanical attenuator/actuator for Space Station docking p 139 N87-29875

Space Station lubrication considerations
p 104 N87-29879

SERVICE MODULES

End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC) — in-orbiting servicing
[FOK-TR-R-86-001-VOL-2] p 102 N87-24466

End effector development study, volume 1 — in-orbit servicing
[FOK-TR-R-86-001-VOL-1] p 102 N87-25336

End effector development study. Volume 3: Appendices — in-orbit servicing
[FOK-TR-R-86-001-VOL-3] p 102 N87-25337

SERVOCONTROL

Control of robot manipulator compliance
p 100 A87-45797

Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445

Theory and application of linear servo dampers for large scale space structures p 72 N87-29870

SERVOMECHANISMS

Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004816] p 101 N87-22231

SHAKERS

Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20688

SHAPE CONTROL

Static shape control for flexible structures
[SAE PAPER 861522] p 13 A87-32888

Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33611

Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0889] p 15 A87-33633

Shape control of the directional pattern in a microwave-beam power transmission channel
p 148 A87-34345

Problems of mechanical system configuration control
p 149 A87-35677

A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502

An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503

Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50508

Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2588] p 62 A87-50561

Dynamic modeling and optimal control design for large flexible space structures p 28 N87-20356

OPUS: Optimal Projection for Uncertain Systems
[AD-A178820] p 29 N87-21025

Large spacecraft pointing and shape control
p 69 N87-24489

Shape design sensitivity analysis and optimal design of structural systems
[NASA-CR-181085] p 37 N87-26370

An investigation of methodology for the control and failure identification of flexible structures
p 38 N87-23821

Effect of bending on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29713

Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-29883

SHEAR STRESS

Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads
[AIAA PAPER 87-0877] p 105 A87-33639

SHOCK ABSORBERS

Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752

SHOCK LAYERS

A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23098

SHOCK TESTS

The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Mast and Ground Shock, Shock Testing and Analysis
[AD-A178294] p 29 N87-20574

SHORT CIRCUITS

Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-38735

MARECS and ECS anomalies: Attempt at irradiation defect production in Kapton p 82 N87-29880

Micrometeorite impact on solar panels — ESA telecommunication satellites p 82 N87-29881

Micrometeorite exposure of solar arrays
p 82 N87-29882

SHUTTLE ENGINEERING SIMULATOR

Flexible spacecraft simulator p 31 N87-22716

SIGNAL PROCESSING

A VHSIC general purpose processor
p 116 N87-29145

Oxygen interaction with space-power materials
[NASA-CR-181380] p 132 N87-29833

SILICON CARBIDES

Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries
p 107 A87-51772

SILICONE RESINS

Space stable thermal control coatings
[AD-A182780] p 110 N87-28664

SILOXANES

Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182823] p 110 N87-27909

SIMULATION

Air Force basic research in dynamics and control of large space structures p 63 N87-20577

Control of flexible structures and the research community p 68 N87-22752

Large space structures testing
[NASA-TM-100000] p 35 N87-24820

Oxygen interaction with space-power materials
[NASA-CR-181380] p 132 N87-29833

SIMULATORS
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-89221] p 137 N87-25339
SINGLE STAGE TO ORBIT VEHICLES
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573
SINGULARITY (MATHEMATICS)
A study on singularity of single gimbal CMG systems p 149 A87-35077
SIZE (DIMENSIONS)
Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870
SLEWING
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47809
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445
Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2586] p 62 A87-50581
Slewing control experiment for a flexible panel p 78 N87-22740
Slew maneuvers on the SCOLE Laboratory Facility p 69 N87-24511
Research in slewing and tracking control p 70 N87-24512
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180808] p 71 N87-25352
Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26036
SLOT ANTENNAS
Carbon fibre slotted waveguide arrays p 85 A87-41302
SOFTWARE ENGINEERING
ESA software engineering standards for future programmes
[AIAA PAPER 87-2207] p 154 A87-48592
Automated software production
[AIAA PAPER 87-2219] p 2 A87-48601
Space operations: NASA's use of information technology. Report to the Chairman, Committee on Science, Space and Technology
[GAO/IMTEC-87-20] p 137 N87-22561
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89295] p 116 N87-29124
A workstation environment for software engineering p 116 N87-29128
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89296] p 116 N87-29144
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155
KSC Space Station Operations Language (SSOL) p 138 N87-29169
SOFTWARE TOOLS
Expert systems in space p 111 A87-32075
TAE Plus: A conceptual view of TAE in the space station era p 9 N87-23157
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412
Advanced software tools space station focused technology p 5 N87-29164
KSC Space Station Operations Language (SSOL) p 138 N87-29169
SOLAR ARRAYS
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32380
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel p 56 A87-32449
Solar array flight dynamic experiment
[AAS PAPER 86-080] p 75 A87-32747
Composite tubes for the Space Station truss structure p 20 A87-38801
Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50509
Modal testing of the Olympus development model solar array p 27 N87-20808
Acoustic effects on the dynamic of lightweight structures p 28 N87-20872
Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 63 N87-20380
SAFE/DAE: Modal test in space p 77 N87-20584
Solar array flight dynamic experiment p 78 N87-22722
Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 78 N87-23695
Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696
Advanced photovoltaic solar array design assessment p 80 N87-26429
High power/large area PV systems p 80 N87-26452
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182586] p 81 N87-28188
Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-28859
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits p 159 N87-28868
The high performance solar array GSR3 p 81 N87-28872
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 82 N87-28873
Improved solar generator technology for the EURECA low Earth orbit p 159 N87-28874
The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-28875
High power solar array technologies — Columbus space station p 82 N87-28876
GaAs concentrator solar arrays p 82 N87-28877
The Fokker Strongback solar array p 82 N87-28879
MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-28880
Micrometeorite impact on solar panels — ESA telecommunication satellites p 82 N87-28881
Micrometeorite exposure of solar arrays p 82 N87-28882
Stopping differential charging of solar arrays p 83 N87-28884
SPOT solar array in-orbit deployment results evaluation p 83 N87-28886
Aerospatiale solar arrays, in orbit performance p 159 N87-28889
Computer simulation of deployment — solar arrays p 10 N87-28902
Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-28904
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-28908
SPOT/MEGS design and flight results obtained — solar array drive (MEGS) p 103 N87-28939
Test results from the solar array flight experiment p 83 N87-29010
The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-29012
Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-28958
SOLAR AUXILIARY POWER UNITS
Preliminary analysis of a prototype space solar power system
[ILR-MITT-180] p 79 N87-24532
SOLAR CELLS
Frequency dispersion in the admittance of the polycrystalline Cu_2S/CdS solar cell p 5 A87-29133
Testing of materials for solar power space applications p 107 A87-53948
An overview of photovoltaic applications in space p 80 N87-26414
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182586] p 81 N87-28188
Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-28859
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits p 159 N87-28868
Improved solar generator technology for the EURECA low Earth orbit p 159 N87-28874
GaAs concentrator solar arrays p 82 N87-28877
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration p 83 N87-28888
Absolute indoor calibration of large area solar cells p 159 N87-29015
SOLAR COLLECTORS
Solar concentrator system for experiments in the Space Station p 146 A87-38685
Structural concepts for large solar concentrators
[NASA-CR-4075] p 65 N87-21884
SOLAR DYNAMIC POWER SYSTEMS
Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system
[SAE PAPER 860966] p 43 A87-38776
Survey of solar-dynamic space power - The Stirling option p 77 A87-42285
A transient analysis of phase change energy storage system for solar dynamic power
[AIAA PAPER 87-1489] p 77 A87-43004
Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 63 N87-20380
Microgravity fluid management requirements of advanced solar dynamic power systems p 77 N87-21153
Structural concepts for large solar concentrators
[NASA-CR-4075] p 65 N87-21884
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-89886] p 78 N87-22174
Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-89883] p 121 N87-23674
Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 78 N87-23695
Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696
Space station electrical power system
[NASA-TM-100140] p 80 N87-28144
Space station power system p 80 N87-26447
Status of space station power system p 84 N87-29915
SOLAR ELECTRIC PROPULSION
Advanced photovoltaic solar array design assessment p 80 N87-26429
SOLAR ENERGY CONVERSION
Advanced photovoltaic solar array design assessment p 80 N87-26429
Alternative power generation concepts for space p 81 N87-28891
SOLAR FLUX
SPOT/MEGS design and flight results obtained — solar array drive (MEGS) p 103 N87-28939
SOLAR GENERATORS
Power plants in space p 158 A87-53660
Performance characteristics of a combination solar photovoltaic heat engine energy converter
[NASA-TM-88903] p 78 N87-23038
IKI department head on orbital power plants p 158 N87-27693
Organic Rankine cycle power conversion systems for space applications p 159 N87-28869
SOLAR MAXIMUM MISSION
Degradation studies of SMRM teflon p 108 A87-38841
SOLAR OPTICAL TELESCOPE
SOT: A rapid prototype using TAE windows p 114 N87-23161
SOLAR ORBITS
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment p 146 A87-34207
SOLAR POWER SATELLITES
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment p 146 A87-34207
The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35789
Solar power satellites — Russian book p 152 A87-44883
Power plants in space p 158 A87-53660
Testing of materials for solar power space applications p 107 A87-53948
Preliminary analysis of a prototype space solar power system
[ILR-MITT-180] p 79 N87-24532
Technology for Large Space Systems. A bibliography with indexes (supplement 17)
[NASA-SP-7046(17)] p 38 N87-25576
SOLAR PROPULSION
A two-dimensional numerical heat transfer model for a solar propulsion system p 74 A87-52956
Testing of materials for solar power space applications p 107 A87-53948
SOLAR RADIATION
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-52948
SOLAR RADIATION SHIELDING
Radiation shielding requirements on long-duration space missions
[AD-A177612] p 140 N87-21891

SOLAR SAILS
Space Station options for constructing advanced solar sails capable of multiple Mars missions
[AIAA PAPER 87-1902] p 91 A87-45287
SOLAR SENSORS
Space Station alpha joint bearing p 83 N87-29882
SOLAR SIMULATORS
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860938] p 150 A87-36728
SOLAR TERRESTRIAL INTERACTIONS
Design considerations for long-lived glass mirrors for space p 123 A87-36531
SOLAR THERMAL PROPULSION
Advanced propulsion activities in the USA
p 90 A87-41575
SOLID MECHANICS
Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 26 N87-20348
SOLID WASTES
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-36794
SOUND TRANSMISSION
Vibrations and structureborne noise in space station
[NASA-CR-181381] p 39 N87-29580
SOVIET SPACECRAFT
Advances by the Soviet Union in space cooperation and commercial marketing made 1986 a landmark year
p 149 A87-34526
The Gagarin scientific lectures in astronautics and aviation, 1985 — Russian book p 152 A87-42623
Mir - A second Sputnik? p 153 A87-48872
SOYUZ SPACECRAFT
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32601
SPACE ADAPTATION SYNDROME
Space motion sickness status report
[SAE PAPER 860923] p 163 A87-36714
SPACE BASED RADAR
Observation of precipitation from space by the weather radar p 145 A87-32507
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88956] p 79 N87-25836
SPACE CHARGE
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26937
Thick dielectric charging on high altitude spacecraft
p 87 N87-26951
SPACE COLONIES
Space colonization - T minus 20 (years) and holding
p 169 A87-32266
SPACE COMMERCIALIZATION
Commercialization of space - The insurance implications p 169 A87-32460
Space Station program in a long-range space development scenario of Japan p 145 A87-32530
Advances by the Soviet Union in space cooperation and commercial marketing made 1986 a landmark year
p 149 A87-34525
The SERVICE concept p 134 A87-36582
The European space programme p 150 A87-37562
Tether power supplies exploiting the characteristics of space
[AAS PAPER 86-227] p 123 A87-38571
Symposium on Microgravity Fluid Mechanics, Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 p 89 A87-38785
Perspectives on materials processing in space
[AAS PAPER 86-189] p 170 A87-53080
Plans for industrialization of space discussed
p 157 N87-21879
SPACE COMMUNICATION
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-29835
Technology for Large Space Systems. A bibliography with indexes (supplement 17)
[NASA-SP-7046(17)] p 39 N87-29576
SPACE DEBRIS
A space debris simulation facility for spacecraft materials evaluation p 11 A87-32659
Orbital debris environment resulting from future activities in space p 139 A87-44382
Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-28981
SPACE ENVIRONMENT SIMULATION
Evaluation testing of a mechanical actuator component operating in a simulated space environment
p 103 A87-32549
Energy expenditure during simulated EVA workloads
[SAE PAPER 860921] p 163 A87-36713
Variable energy, high flux, ground-state atomic oxygen source
[NASA-CASE-NPO-16640-1-CU] p 8 N87-21861
Proceedings of the NASA Workshop on Atomic Oxygen Effects — low earth orbital environment
[NASA-CR-181163] p 141 N87-26173
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-26186
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 121 N87-26188
Pulsed source of energetic atomic oxygen
p 109 N87-26189
NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-26202
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-26204
Micrometeorite exposure of solar arrays
p 82 N87-29862
SPACE ERECTABLE STRUCTURES
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32729
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0868] p 14 A87-33632
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33709
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-34487
Thermal design of the ACCESS erectable space truss
p 42 A87-34489
Large space antennas: A systems analysis case history
[NASA-TM-89072] p 28 N87-20352
Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 83 N87-20380
Status of the Mast experiment p 30 N87-22703
Design, construction, and utilization of a space station assembled from 5-meter erectable struts
p 34 N87-24001
COFS 3 multibody dynamics and control technology
p 69 N87-24508
Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24509
Bi-stem gripping apparatus
[NASA-CASE-MFS-28185-1] p 107 N87-25588
Space station systems: A bibliography with indexes (supplement 4)
[NASA-SP-7056(04)] p 4 N87-26073
Remote handling facility and equipment used for space truss assembly
[DE87-008121] p 103 N87-27409
The 21st Aerospace Mechanisms Symposium
[NASA-CP-2470] p 103 N87-29858
Folding, articulated, square truss p 40 N87-29859
SPACE EXPLORATION
International cooperation in space
p 149 A87-34524
A survey of tether applications to planetary exploration
[AAS PAPER 86-200] p 123 A87-38569
Space the next twenty-five years — Book
p 169 A87-44375
Man's role in space exploration and exploitation
p 169 A87-48232
Prospects for space science
[AAS PAPER 86-183] p 170 A87-53085
Technology projections and space systems opportunities for the 2000-2020 time period
[AAS PAPER 86-188] p 2 A87-53088
National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-25024
Military man in space: A history of Air Force efforts to find a manned space mission
[AD-A178373] p 171 N87-25915
USSR Report: Space
[JPRS-USP-86-004] p 156 N87-27587
National Aeronautics and Space Administration
p 172 N87-28029
SPACE FLIGHT
Superfluid helium on orbit transfer (SHOOT)
p 89 N87-21151
Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-008497] p 171 N87-22697
Optimal nodal transfer and consolidated transfer by aerocapture p 130 N87-29877
Optimizing experimental programs in operational planning of research carried out from spacecraft
p 160 N87-29553
SPACE FLIGHT FEEDING
Foods and nutrition in space
[SAE PAPER 860926] p 47 A87-36716
Space Station Food System
[SAE PAPER 860930] p 48 A87-36720
Space Station galley design
[SAE PAPER 860932] p 119 A87-36722
SPACE FLIGHT STRESS
Physiological aspects of EVA
[SAE PAPER 860991] p 164 A87-36768
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735
SPACE FLIGHT TRAINING
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180342] p 53 N87-27405
SPACE HABITATS
Habitation module for the Space Station
[SAE PAPER 860928] p 163 A87-36718
Habitability issues for the Science Laboratory Module
[SAE PAPER 860971] p 50 A87-36753
Space station: A program overview
p 171 N87-24486
SPACE INDUSTRIALIZATION
Tether power supplies exploiting the characteristics of space
[AAS PAPER 86-227] p 123 A87-38571
The Industrial Space Facility p 167 A87-38579
The industrial use of Spacelab p 169 A87-42298
Solar power satellites — Russian book
p 152 A87-44883
SPACE INFRARED TELESCOPE FACILITY
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32736
SPACE LABORATORIES
Special considerations in outfitting a space station module for scientific use
[SAE PAPER 860956] p 164 A87-36741
Science Research Facilities - Versatility for Space Station
[SAE PAPER 860958] p 119 A87-36742
Habitability issues for the Science Laboratory Module
[SAE PAPER 860971] p 50 A87-36753
Life Science Research Facility materials management requirements and concepts
[SAE PAPER 860974] p 124 A87-36756
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-36757
SPACE LAW
The station is raising lots of questions about space law p 167 A87-34587
Legal problems concerning manned space flight — Russian book p 151 A87-40339
Present and future military uses of outer space: international law, politics, and the practice of states
[AD-A176722] p 170 N87-21753
Space stations and the law: Selected legal issues
[PB87-118230] p 171 N87-21754
SPACE LOGISTICS
Satellite servicing logistics
[SAE PAPER 861723] p 132 A87-32812
SPACE MAINTENANCE
Hubble Space Telescope satellite servicing
[SAE PAPER 861785] p 133 A87-32844
User interface design guidelines for expert troubleshooting systems — for Space Station
p 6 A87-33030
Advanced orbital servicing capabilities development
[SAE PAPER 860897] p 134 A87-36703
Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 83 A87-36779
On-orbit assembly and repair p 135 A87-40579
Planning for space robotics developments and applications p 136 A87-40877
Robots on the Space Station p 100 A87-40844
Concepts for space maintenance of OTV engines
p 135 A87-41161
A proposal for space tether damage indication, location, and evaluation - The Repair Monkey Module
p 125 A87-45554
Servicing of the polar platform — Columbus space station p 136 N87-26926
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A179897] p 120 N87-27762
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replacement
[AD-A179160] p 161 N87-28077

End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC) -- in-orbiting servicing
[FOK-TR-R-86-091-VOL-2] p 102 N87-24486
End effector development study, volume 1 -- in-orbit servicing
[FOK-TR-R-86-091-VOL-1] p 102 N87-25336
End effector development study. Volume 3: Appendices -- in-orbit servicing
[FOK-TR-R-86-091-VOL-3] p 102 N87-25337
Concepts for space maintenance of OTV engines p 137 N87-26097
Space Station lubrication considerations p 104 N87-29879
Space Station alpha joint bearing p 83 N87-29882

SPACE MANUFACTURING
The mechanics of manufacturing in space p 167 A87-43088
Process control and data acquisition for commercial materials processing in space
[AIAA PAPER 87-2187] p 113 A87-48583
Development of a small-sized space manipulator p 101 A87-51879
Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-20311
Plans for industrialization of space discussed p 157 N87-21979
Active vibration control in microgravity environment p 72 N87-26700

SPACE MISSIONS
Space research - At a crossroads p 169 A87-32017
Technology projections and space systems opportunities for the 2000-2030 time period
[AAS PAPER 86-108] p 2 A87-53088
Space 2000 in Europe p 159 N87-20034
LEO and GEO missions p 5 N87-29916
JPL future missions and energy storage technology implications p 84 N87-29917

SPACE NAVIGATION
Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744
GPS applications to the Space Station p 139 A87-45525

SPACE OBSERVATIONS (FROM EARTH)
Infra-red astronomy after IRAS p 127 A87-54187

SPACE PLASMAS
Hollow cathode-based plasma contactor experiments for electrodynamic tether
[AIAA PAPER 87-0572] p 121 A87-32182
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-215] p 69 A87-33089
Theory of plasma contactors for electrodynamic tethered satellite systems p 85 A87-41889
Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit
[NASA-TM-89116] p 68 N87-20339
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181084] p 140 N87-23338
Electron beam experiments at high altitudes p 142 N87-25846
Automatic charge control system for geosynchronous satellites p 67 N87-26860

SPACE PLATFORMS
Expert systems in space p 111 A87-32075
The Space Station - Work Package 3 p 116 A87-32520
Advanced technology experiment onboard space platform p 122 A87-32530
Design of a polar platform with an earth observation payload p 122 A87-32532
Concept design and cost estimation of a free-flying space platform p 146 A87-32533
On-orbit fluid management p 132 A87-32545
Magnetic refrigeration for space platforms
[SAE PAPER 861734] p 116 A87-32913
Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms
[AAS PAPER 86-041] p 133 A87-32743
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-34497
Communication missions for geostationary platforms p 84 A87-34797
Mechanical design of the Eureka platform p 140 A87-34874
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860935] p 42 A87-38725
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-39889
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-39829
Communication and Data Management Systems for an orbiting platform p 112 A87-40259
A three-mass tethered system for micro-g/variable-g applications p 125 A87-40859
A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K. p 125 A87-41430
The evolution of the geostationary platform concept p 125 A87-43154
An advanced geostationary communications platform p 125 A87-43165
Earth resources instrumentation for the Space Station Polar Platform p 126 A87-44184
The Earth Observing System (EOS) synthetic aperture radar (SAR) p 126 A87-44187
A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50582
Microgravity experiments onboard Eureca p 155 A87-53554
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-263] p 129 N87-20821
The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 129 N87-20822
Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 129 N87-20825
ESA Columbus polar platform design concept p 159 N87-20827
Servicing of the polar platform -- Columbus space station p 139 N87-20828
Orbit configurations -- space station polar platform p 159 N87-20829
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20830
Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects) p 129 N87-20831
USA-Europe coordination and cooperation activities: Announcements of Opportunity -- polar platforms p 170 N87-20832
Report of the atmosphere panel p 161 N87-20833
Land panel report -- International Space Station p 129 N87-20834
Ocean-ice panel report -- International Space Station p 159 N87-20835
Solid Earth panel report -- Columbus program p 157 N87-20836
Panel report on multidisciplinary instrumentation: New possibilities -- Columbus space station p 161 N87-20837
Data management panel report -- Columbus polar platforms p 114 N87-20838
The orbit configuration panel report -- Columbus polar platforms p 157 N87-20840
Panel report on the polar platform servicing approach and its implications -- Columbus space station p 139 N87-20841
Research in slewing and tracking control p 70 N87-24612
Space station systems: A bibliography with indexes (supplement 4)
[NASA-SP-7056(04)] p 4 N87-28873
Propulsion recommendations for space station free flying platforms p 93 N87-29129
The evolution of a serviceable EURECA
[MBB-UR-E-925/86] p 121 N87-29941
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 100 N87-29118
Phase II study of selected tether applications in space. Volume 1: Executive summary
[NASA-CR-179183] p 131 N87-29935

SPACE POWER REACTORS
ERATO orbital transfer vehicle with electronuclear power - Study of the associated electronuclear generator p 75 A87-38844
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41146
Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154
Coaxial tube array space transmission line characterization
[NASA-TM-89864] p 86 N87-22303
Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-88863] p 121 N87-23674

SPACE POWER UNIT REACTORS
Alternative power generation concepts for space p 81 N87-29881

SPACE PROCESSING
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6 p 147 A87-32814
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-39838
The mechanics of manufacturing in space p 167 A87-43088
Process control and data acquisition for commercial materials processing in space
[AIAA PAPER 87-2187] p 113 A87-48583
Perspectives on materials processing in space
[AAS PAPER 86-103] p 170 A87-53083
Microgravity experiments onboard Eureca p 155 A87-53554
Plans for industrialization of space discussed p 157 N87-21979
Active vibration control in microgravity environment p 72 N87-26700
Progress in theory, technology of space materials science p 156 N87-27665

SPACE PROGRAMS
International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volumes 1 & 2 p 169 A87-32279
EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 p 2 A87-40261
Space the next twenty-five years -- Book p 169 A87-44375
Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-48586
The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53082
Prospects for space science
[AAS PAPER 86-106] p 170 A87-53086
Technology projections and space systems opportunities for the 2000-2030 time period
[AAS PAPER 86-108] p 2 A87-53088
Human capabilities in space
[AAS PAPER 86-114] p 166 A87-53090

SPACE RATIONS
Space Station Food System
[SAE PAPER 860930] p 46 A87-38720
Space Station galley design
[SAE PAPER 860932] p 118 A87-38722

SPACE RENDEZVOUS
Mir in action p 150 A87-37671
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41815
Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-48158
Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54188
Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-618/86] p 139 N87-26603

SPACE SHUTTLE MISSION 41-D
Test results from the solar array flight experiment p 83 N87-29910

SPACE SHUTTLE MISSION 61-B
Thermal design of the ACCESS erectable space truss p 42 A87-34469

SPACE SHUTTLE MISSIONS
Space Shuttle flight rates and utilization p 1 A87-37663

SPACE SHUTTLE ORBITERS
Living in space: A handbook for space travellers p 162 A87-30475
Manned spacecraft electrical power systems p 75 A87-37291
Shuttle orbit flight control design lessons - Direction for Space Station p 53 A87-37295
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42917
Mass property estimation for control of asymmetrical satellites p 60 A87-52808
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22703

Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-89221] p 137 N87-25339

The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29865

Space Station based options for orbiter docking/berthing p 138 N87-29877

SPACE SHUTTLE PAYLOADS

Solar array flight dynamic experiment
[AAS PAPER 86-050] p 75 A87-32747

Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-210] p 89 A87-36589

Liquid droplet radiator development status -- waste heat rejection devices for future space vehicles
[AIAA PAPER 87-1537] p 43 A87-43059

The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450

Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 136 N87-20308

Use of lightweight composites for GAS payload structures p 25 N87-20307

Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-20311

The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325

Satellite servicing mission preliminary cost estimation model
[NASA-CR-171976] p 135 N87-20335

Liquid droplet radiator development status
[NASA-TM-89852] p 44 N87-20423

Influence coefficient testing as a substitute for modal survey testing of large space structures
p 27 N87-20888

Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 83 N87-20380

Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21158

Structural/control interaction (payload pointing and micro-g) p 9 N87-22721

Contamination assessment for OSSA space station IOC payloads
[NASA-CR-181166] p 141 N87-26062

Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4091] p 53 N87-26066

SPACE SHUTTLE UPPER STAGES

Commercial US transfer vehicle overview
[SAE PAPER 861794] p 1 A87-32625

NERVA derived nuclear orbit transfer system
[AIAA PAPER 87-2155] p 92 A87-45439

SPACE SHUTTLES

The Industrial Space Facility p 167 A87-38579

The mechanics of manufacturing in space
p 167 A87-40988

The Soviet space shuttle programme
p 153 A87-47302

Ram ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51713

Influence coefficient testing as a substitute for modal survey testing of large space structures
p 27 N87-20888

Servicing of the polar platform -- Columbus space station p 138 N87-20928

Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-73-418] p 171 N87-22580

Optimal shuttle attitude changes using tethers
[AD-A178206] p 129 N87-22756

National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240

Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24505

Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26038

NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988
[GPO-73-248] p 172 N87-30021

SPACE SIMULATORS

Space Station EVA simulation demonstrates orbital assembly p 132 A87-32309

A space debris simulation facility for spacecraft materials evaluation p 11 A87-32552

Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32356

Computer simulation of on-orbit manned maneuvering unit operations
[SAE PAPER 861783] p 47 A87-32602

A simulation capability for future space flight
[SAE PAPER 861784] p 68 A87-32603

Design and development of a Space Station proximity operations research and development mockup
[SAE PAPER 861785] p 133 A87-32604

High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-26188

Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 131 N87-26189

Pulsed source of energetic atomic oxygen
p 109 N87-26190

Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-26204

SPACE STATION PAYLOADS

On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32523

Design of a polar platform with an earth observation payload p 122 A87-32528

Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860952] p 164 A87-38740

Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860973] p 134 A87-38755

Linear quadratic control system design for Space Station pointed payloads
[AIAA PAPER 87-2530] p 161 A87-50522

Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20930

Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects)
p 120 N87-20931

An astrometric facility for planetary detection on the space station
[NASA-TM-89438] p 129 N87-20941

Impact of space station appendage vibrations on the pointing performance of gimballed payloads
p 32 N87-22733

Optimization of payload mass placement in a dual keel space station
[NASA-TM-89091] p 69 N87-23887

Botanical payloads for platforms and space stations
[MBB-UR-E-921/86] p 159 N87-25340

Contamination assessment for OSSA space station IOC payloads
[NASA-CR-181166] p 141 N87-26062

Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4091] p 53 N87-26066

SPACE STATION POLAR PLATFORMS

Design of a polar platform with an earth observation payload p 122 A87-32528

A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K.
p 125 A87-41436

Space Station opportunity for UK in earth sensing
p 152 A87-41679

Earth resources instrumentation for the Space Station Polar Platform p 129 A87-44184

The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50582

Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-268] p 129 N87-20921

The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 120 N87-20922

Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group)
p 129 N87-20925

ESA Columbus polar platform design concept
p 156 N87-20927

Servicing of the polar platform -- Columbus space station p 138 N87-20928

Orbit configurations -- space station polar platform
p 158 N87-20929

Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20930

Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects)
p 120 N87-20931

USA-Europe coordination and cooperation activities: Announcements of Opportunity -- polar platforms
p 170 N87-20932

Report of the atmosphere panel p 161 N87-20933

Land panel report -- International Space Station
p 129 N87-20934

Solid Earth panel report -- Columbus program
p 157 N87-20936

Panel report on new approaches to calibration and validation -- Columbus polar platforms
p 157 N87-20938

Data management panel report -- Columbus polar platforms p 114 N87-20939

The orbit configuration panel report -- Columbus polar platforms p 157 N87-20940

Panel report on the polar platform servicing approach and its implications -- Columbus space station
p 138 N87-20941

SPACE STATION POWER SUPPLIES

Expert systems in space p 111 A87-32075

Solar concentrator system for experiments in the Space Station p 148 A87-32535

Power management equipment for space applications
[SAE PAPER 861621] p 74 A87-32578

An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579

Advanced technology for extended endurance alkaline fuel cells p 75 A87-32787

Intelligent flywheel energy storage units with additional functions for future space stations in near-earth orbits
[DGLR PAPER 86-172] p 57 A87-36792

Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system
[SAE PAPER 860859] p 43 A87-38776

20 kHz Space Station power system
p 76 A87-40079

Survey of solar-dynamic space power - The Stirling option p 77 A87-42385

A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system
[AIAA PAPER 87-2487] p 77 A87-50511

Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54168

Space station electric power system requirements and design
[NASA-TM-89889] p 68 N87-22001

Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-88883] p 121 N87-22074

Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 78 N87-23688

Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23689

Status of space station power system
p 84 N87-26915

Advanced fuel cell concepts for future NASA missions
p 89 N87-26695

Regenerative fuel cells for space applications
p 84 N87-26696

SPACE STATION PROPULSION

The use of electric propulsion on low earth orbit spacecraft
[AIAA PAPER 87-0990] p 59 A87-36663

Dynamic behavior of astronauts and satellites outside an orbiting space station under the influence of thrust
p 52 A87-41699

Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1859] p 91 A87-45255

Conceptual design and integration of a Space Station resistojet propulsion assembly
[AIAA PAPER 87-1860] p 91 A87-45256

The impact of integrated water management on the Space Station propulsion system
[AIAA PAPER 87-1864] p 91 A87-45259

Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 62 A87-52252

Conceptual design and integration of a space station resistojet propulsion assembly
[NASA-TM-88847] p 93 N87-20376

Density uncertainty effect on cost of space station reboost p 170 N87-20687

Space station momentum management
p 84 N87-20868

Space station control moment gyro control
p 84 N87-20869

Hydrogen/oxygen economy for the space station
p 89 N87-29129

Space station propulsion test bed: A complete system
p 89 N87-29131

A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 89 N87-29132

Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 89 N87-29133

Space station propulsion-ECLSS interaction study
[NASA-CR-179380] p 54 N87-29534

SPACE STATION STRUCTURES

Development of exposed deck of Japanese experiment module p 145 A87-32532
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
Study of actuator for large space manipulator arm p 12 A87-32545
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548
Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 861828] p 41 A87-32862
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33584
Composite tubes for the Space Station truss structure p 20 A87-38801
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41613
Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2598] p 62 A87-50508
Space station structures and dynamics test program
[NASA-TP-2710] p 28 N87-20508
Considerations in the design and development of a space station scale model p 9 N87-22711
Dual keel space station control/structures interaction study p 67 N87-22737
Space station structures and dynamics test program p 23 N87-22751
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
Adaptive momentum management for large space structures
[NASA-CR-178085] p 67 N87-22758
Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178090] p 10 N87-24758

SPACE STATIONS

Space Station integration and verification concepts p 84 A87-31481
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31482
Head-ported display analysis for Space Station applications p 111 A87-31485
Space Station EVA simulation demonstrates orbital assembly p 132 A87-32090
Selected materials issues associated with Space Station p 105 A87-32191
Determination of the cross-sectional temperature distribution and boiling limitation of a heat pipe p 40 A87-32175
NASA's space program - Space Station: A status report and a view of its value for space science p 1 A87-32277
High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-32377
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 48 A87-32455
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
Gas and water recycling system for IOC vivarium experiments -- Initial Operational Capacity p 48 A87-32457
Water recycling system using thermopervaporation method p 48 A87-32458
Water recycling for Space Station p 48 A87-32459
Space Station - Overview of the European concept of Columbus programme status and content p 145 A87-32525
The Space Station - Work Package 3 p 118 A87-32526
Space Station program in a long-range space development scenario of Japan p 145 A87-32530
Status of Japanese Experiment Module design p 145 A87-32531
Development of exposed deck of Japanese experiment module p 145 A87-32532
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
Eureca - A first step towards the Space Station p 146 A87-32537
Design of a polar platform with an earth observation payload p 122 A87-32538
Payload levitating technology for space experiments at very low gravity level p 146 A87-32540
Autonomous decentralized system concept for Space Station p 146 A87-32541
Japanese experiment module data management and communication system p 147 A87-32542
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station p 46 A87-32544
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548
Evaluation testing of a mechanical actuator component operating in a simulated space environment p 160 A87-32549
Magnetic refrigeration for space platforms
[SAE PAPER 861734] p 118 A87-32813
Design and development of a Space Station proximity operations research and development mockup
[SAE PAPER 861780] p 133 A87-32834
Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32863
Environmental avoidance concepts for steerable Space Station radiators
[SAE PAPER 861831] p 41 A87-32865
Role of the manned maneuvering unit for the Space Station
[SAE PAPER 861834] p 133 A87-32867
Prototype thermal bus for manned Space Station components
[SAE PAPER 861825] p 41 A87-32868
System level verification applying the Space Shuttle experience to the Space Station
[AAS PAPER 86-001] p 55 A87-32727
The Softmounted Inertially Reacting Pointing System (SIRPNT)
[AAS PAPER 86-007] p 58 A87-32732
Stability in the relative equilibrium positions of space stations at triangular libration points in the photogravitational three-body problem p 1 A87-32852
ISOKIN - A quantitative model of the kinesthetic aspects of spatial habitability p 162 A87-33052
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station p 118 A87-33053
An evaluation of menu systems for Space Station interfaces p 111 A87-33045
User interface design guidelines for expert troubleshooting systems -- for Space Station p 6 A87-33050
Living in space: A handbook for space travelers p 162 A87-33475
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33584
Modal analyses of dynamics of a deformable multibody spacecraft - The Space Station: A continuum approach
[AIAA PAPER 87-0925] p 17 A87-33727
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731
The station is raising lots of questions about space law p 167 A87-34067
Space Station - Opportunities for the life sciences p 122 A87-34671
Development of harmonic drive actuator for space manipulator p 149 A87-35579
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35232
Safety on the Space Station p 162 A87-35585
When the doctor is 200 miles away p 47 A87-35586
Design considerations for long-lived glass mirrors for space p 129 A87-35631
Space Station 20-kHz power management and distribution system p 75 A87-36913
Space Station data management system architecture p 111 A87-37285
Space station data management system - A common GSE test interface for systems testing and verification p 112 A87-37294
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295
Space Station communications and tracking system p 184 A87-37297
Real-time simulation for Space Station p 7 A87-37298
Manned spacecraft automation and robotics p 100 A87-37300
Space Shuttle flight rates and utilization p 1 A87-37303
Plumbing on Space Station cooperation? p 150 A87-37304
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings p 167 A87-38576
The Industrial Space Facility p 167 A87-38579
Composite tubes for the Space Station truss structure p 20 A87-38801
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration
[SAE PAPER 860916] p 47 A87-38708
EDC development and testing for the Space Station program -- Electrochemical Carbon Dioxide Concentration
[SAE PAPER 860919] p 118 A87-38710
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712
Radiation dose prediction for Space Station
[SAE PAPER 860924] p 139 A87-38715
Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation
[SAE PAPER 860927] p 163 A87-38717
Habitation module for the Space Station
[SAE PAPER 860929] p 163 A87-38718
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720
Space Station personal hygiene study
[SAE PAPER 860931] p 163 A87-38721
Space Station galley design
[SAE PAPER 860932] p 119 A87-38722
A maintenance work station for Space Station
[SAE PAPER 860933] p 167 A87-38723
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724
System aspects of Columbus thermal control
[SAE PAPER 860938] p 150 A87-38727
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-38729
Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 48 A87-38730
Environmental Control Life Support for the Space Station
[SAE PAPER 860944] p 48 A87-38731
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements
[SAE PAPER 860945] p 48 A87-38732
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733
Evaluation of regenerative portable life support system options
[SAE PAPER 860948] p 48 A87-38735
Space Station life support oxygen generation by SPE water electrolyzer systems
[SAE PAPER 860949] p 49 A87-38736
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860952] p 164 A87-38740
Special considerations in outfitting a space station module for scientific use
[SAE PAPER 860953] p 164 A87-38741
Science Research Facilities - Versatility for Space Station
[SAE PAPER 860956] p 119 A87-38742
Columbus Life Support System and its technology development
[SAE PAPER 860965] p 150 A87-38746
An evolutionary approach to the development of a CELSS based air revitalization system
[SAE PAPER 860968] p 49 A87-38750
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 860969] p 164 A87-38751
Life Sciences Research Facility automation requirements and concepts for the Space Station
[SAE PAPER 860970] p 50 A87-38752
Habitability issues for the Science Laboratory Module
[SAE PAPER 860971] p 50 A87-38753
Concepts for the evolution of the Space Station Program
[SAE PAPER 860972] p 120 A87-38754
Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860973] p 134 A87-38755
Life Science Research Facility materials management requirements and concepts
[SAE PAPER 860974] p 124 A87-38756
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-38757
Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860976] p 42 A87-38760
Pre- and post-treatment techniques for spacecraft water recovery
[SAE PAPER 860982] p 50 A87-38761
Phase change water recovery for Space Station - Parametric testing and analysis
[SAE PAPER 860985] p 51 A87-38765
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs
[SAE PAPER 860987] p 51 A87-38766
Space Station EVA systems trade-off model
[SAE PAPER 860993] p 134 A87-38767

Advanced orbital servicing capabilities development
[SAE PAPER 860992] p 134 A87-38769
Supercritical water oxidation - Concept analysis for evolutionary Space Station application
[SAE PAPER 860993] p 51 A87-38770
CELSS waste management systems evaluation
[SAE PAPER 860997] p 51 A87-38774
Evaluation of Space Station thermal control techniques
[SAE PAPER 860998] p 42 A87-38775
Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 89 A87-38778
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 861007] p 52 A87-38779
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
An evaluation of advanced extravehicular crew enclosures
[SAE PAPER 861009] p 134 A87-38781
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-38782
The next step for the MMU - Capabilities and enhancements
[SAE PAPER 861013] p 180 A87-38783
The mechanics of manufacturing in space
p 167 A87-40088
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-40098
Advanced technology for the Space Station
p 120 A87-40353
An operations management system for the Space Station p 112 A87-40358
Complex system monitoring and fault diagnosis using communicating expert systems p 119 A87-40363
On-orbit assembly and repair p 135 A87-40376
Planning for space robotics developments and applications p 135 A87-40377
20 kHz Space Station power system
p 76 A87-40378
On-board communications, including EVA
p 85 A87-40380
On board Data Management p 112 A87-40381
The Space Station - Uses and users
p 151 A87-40513
Robots on the Space Station p 100 A87-40844
Orbital modifications using forced tether-length variations p 124 A87-40858
A three-mass tethered system for micro-g/variable-g applications p 125 A87-40859
Resistojet control and power for high frequency ac busses
[AIAA PAPER 87-0994] p 58 A87-41103
The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 100 A87-41153
Columbus/Space Station United Kingdom Utilisation Study 1985/6 Report - Executive Summary
p 151 A87-41429
The Space Station overview p 168 A87-41571
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41613
Space Station opportunity for UK in earth sensing
p 152 A87-41679
A model for the estimation of the operations and utilisation costs of an international space station
p 168 A87-42287
Space station active thermal control system modelling
[AIAA PAPER 87-1468] p 43 A87-43003
The benefit of phase change thermal storage for spacecraft thermal management
[AIAA PAPER 87-1482] p 43 A87-43014
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1489] p 90 A87-43027
Liquid droplet radiator development status -- waste heat rejection devices for future space vehicles
[AIAA PAPER 87-1537] p 43 A87-43059
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43100
External contamination environment of Space Station Customer Servicing Facility
[AIAA PAPER 87-1623] p 52 A87-43122
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125
Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1628] p 44 A87-43126
Space-based OTV boiloff disposition
[AIAA PAPER 87-1767] p 91 A87-45191
Operation of the orbital spacecraft consumables resupply system (OSCRS) at the Space Station
[AIAA PAPER 87-1768] p 135 A87-45192
Space Station options for constructing advanced solar sails capable of multiple Mars missions
[AIAA PAPER 87-1902] p 91 A87-45287
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results
[AIAA PAPER 87-2157] p 180 A87-45441
FDMA system design and analysis for Space Station
p 85 A87-45483
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel
p 113 A87-45485
Multiple beam phased array for Space Station Control Zone Communications p 85 A87-45519
Space Station tracking subsystem sensor evaluation
p 85 A87-45520
A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521
End-to-end communications for Space Station
p 85 A87-45522
Antenna systems and RF coverage for the Space Station p 2 A87-45523
Space Station multiple access communications system p 86 A87-45524
GPS applications to the Space Station
p 128 A87-45525
Man's role in space exploration and exploitation
p 169 A87-46332
We shouldn't build the Space Station now
p 169 A87-46875
The Space Station: A personal journey -- Book
p 169 A87-46975
Space Station business p 168 A87-47726
Space Station - The next logical step
p 169 A87-47888
The problem of radiation exposure in the Space Station
[DGLR PAPER 86-175] p 153 A87-48157
Japanese customer needs for Space Station
[AIAA PAPER 87-2183] p 153 A87-48580
Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2185] p 153 A87-48581
Scientific customer needs - NASA user
[AIAA PAPER 87-2186] p 119 A87-48582
Process control and data acquisition for commercial materials processing in space
[AIAA PAPER 87-2187] p 113 A87-48583
Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48587
Data capture and processing -- for Space Station
[AIAA PAPER 87-2203] p 113 A87-48588
The Space Station software support environment - Not just what, but why
[AIAA PAPER 87-2208] p 114 A87-48593
Standards for the user interface - Developing a user consensus -- for Space Station Information System
[AIAA PAPER 87-2209] p 169 A87-48594
Integrated scheduling and resource management -- for Space Station Information System
[AIAA PAPER 87-2213] p 119 A87-48597
Technical and Management Information System (TMIS)
[AIAA PAPER 87-2217] p 114 A87-48600
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48602
Space Station Information System integrated communications concept
[AIAA PAPER 87-2228] p 114 A87-48606
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2229] p 114 A87-48607
Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-49030
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 93 A87-50187
Control/dynamics simulation for preliminary Space Station design
[AIAA PAPER 87-2441] p 61 A87-50486
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531
Linear quadratic control system design for Space Station pointed payloads
[AIAA PAPER 87-2530] p 161 A87-50533
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50582
An astrometric facility for planetary detection on the Space Station p 127 A87-50750
Space Station - All change? p 154 A87-50792
Development of a small-sized space manipulator
p 101 A87-51979
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002
Space Station autonomy - What are the challenges? How can they be met? p 101 A87-53059
Perspectives on materials processing in space
[AAS PAPER 86-103] p 170 A87-53083
Operational instruments on the Space Station-Polar Platforms - Contributions by NOAA and the international community p 127 A87-53149
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53679
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340
Fire safety concerns in space operations
[NASA-TM-89848] p 165 N87-20342
Advanced EVA system design requirements study: EVAS/space station system interface requirements
[NASA-CR-171991] p 120 N87-20351
Liquid droplet radiator development status
[NASA-TM-89852] p 44 N87-20353
Resistojet control and power for high frequency ac busses
[NASA-TM-88980] p 60 N87-20477
Space station structures and dynamics test program
[NASA-TP-2710] p 29 N87-20569
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-268] p 128 N87-20821
The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 128 N87-20822
The Columbus program: An overview
p 156 N87-20823
European utilisation aspects studies -- space stations
p 156 N87-20824
ESA Columbus polar platform design concept
p 156 N87-20827
Servicing of the polar platform -- Columbus space station p 136 N87-20828
Orbit configurations -- space station polar platform
p 156 N87-20829
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20830
Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects)
p 128 N87-20831
USA-Europe coordination and cooperation activities: Announcements of Opportunity -- polar platforms
p 170 N87-20832
Land panel report -- International Space Station
p 128 N87-20834
Ocean-ice panel report -- International Space Station
p 156 N87-20835
Solid Earth panel report -- Columbus program
p 157 N87-20836
Panel report on multidisciplinary instrumentation: New possibilities -- Columbus space station
p 161 N87-20837
Panel report on new approaches to calibration and validation -- Columbus polar platforms
p 157 N87-20838
Data management panel report -- Columbus polar platforms p 114 N87-20839
The orbit configuration panel report -- Columbus polar platforms p 157 N87-20840
Panel report on the polar platform servicing approach and its implications -- Columbus space station
p 136 N87-20841
Density uncertainty effect on cost of space station reboost p 170 N87-20857
Documentation of the space station/aircraft acoustic apparatus
[NASA-TM-89111] p 140 N87-20895
An astrometric facility for planetary detection on the space station
[NASA-TM-89438] p 128 N87-20941
The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary
[NASA-CR-178278] p 8 N87-21020
Wave-mode coordinates and scattering matrices for wave propagation
[AD-A178683] p 29 N87-21030

Space station experiment definition: Long term cryogenic fluid storage p 94 N87-21144
Maintenance evaluation for space station liquid systems p 52 N87-21155
Space station group activities habitability module study
[NASA-CR-4010] p 165 N87-21585
Space stations and the law: Selected legal issues
[PB87-118220] p 171 N87-21754
Plans for industrialization of space discussed
p 157 N87-21979
Equations of motion of a space station with emphasis on the effects of the gravity gradient
[NASA-TM-89588] p 64 N87-21983
The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178192] p 9 N87-21995
Space station electric power system requirements and design
[NASA-TM-88886] p 86 N87-22001
Coaxial tube array space transmission line characterization
[NASA-TM-88884] p 86 N87-22003
EMC and power quality standards for 20-kHz power distribution
[NASA-TM-88925] p 78 N87-22004
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004816] p 101 N87-22231
Traction-drive telerobot for space manipulation
[DE87-005328] p 102 N87-22233
Telerobotic technology for nuclear and space applications
[NASA-CR-180823] p 102 N87-22242
Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-22457
Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-73-418] p 171 N87-22580
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22709
Considerations in the design and development of a space station scale model p 9 N87-22711
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 68 N87-22729
Impact of space station appendage vibrations on the pointing performance of gimballed payloads
p 32 N87-22730
Preliminary evaluation of a reaction control system for the space station p 67 N87-22736
Dual keel space station control/structures interaction study p 67 N87-22737
Slewing control experiment for a flexible panel
p 76 N87-22740
Crew activity and motion effects on the space station
p 165 N87-22744
Space station structures and dynamics test program
p 33 N87-22751
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
Adaptive momentum management for large space structures
[NASA-CR-178995] p 67 N87-22756
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A178887] p 120 N87-22762
The effect of multipath on digital communications systems: With application to space station
[AD-A178578] p 88 N87-22876
Performance characteristics of a combination solar photovoltaic heat engine energy converter
[NASA-TM-88909] p 78 N87-23029
A systems analysis of emergency escape and recovery systems for the US space station
[AD-A178233] p 3 N87-23680
An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A178235] p 68 N87-23681
A multiple attribute decision analysis of manned airlock systems
[AD-A178241] p 137 N87-23682
Optimization of payload mass placement in a dual keel space station
[NASA-TM-89051] p 68 N87-23687
Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88980] p 68 N87-23690
Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 79 N87-23695
Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 98 N87-23821
Application of advanced flywheel technology for energy storage on space station
[DE87-007657] p 68 N87-24026
Guidelines for noise and vibration levels for the space station
[NASA-CR-178310] p 120 N87-24162
National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240
NASA/DOD Control/Structures Interaction Technology, 1986
[NASA-CP-2447-PT-2] p 34 N87-24495
Space station: A program overview
p 171 N87-24498
Large space systems technology and requirements
p 3 N87-24500
Design, construction, and utilization of a space station assembled from 5-meter erectable struts
p 34 N87-24501
Assessment of space station power system
[ATES-AN-86/488] p 75 N87-24530
Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2318] p 79 N87-24533
Space station experiment definition: Long-term cryogenic fluid storage
[NASA-CR-4072] p 97 N87-24641
Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178889] p 10 N87-24709
The Columbus program p 157 N87-25031
Ideas for educational physics experiments in space
p 130 N87-25033
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-88821] p 137 N87-25339
Botanical payloads for platforms and space stations
[MBB-UR-E-821/86] p 158 N87-25340
Possibilities of the further development of Columbus to an autonomous European space station
[MBB-UR-E-822/86] p 158 N87-25418
Space station propulsion system technology
[NASA-TM-100108] p 97 N87-25422
Electrochemical processing of solid waste
[NASA-CR-181129] p 137 N87-25443
The Radarsat Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25508
Vapor fragrancer
[NASA-CASE-LAR-13650-1] p 165 N87-25561
Collect lock joint for space station truss
[NASA-CASE-MSC-21207-1] p 36 N87-25576
Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11288-1] p 102 N87-25583
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 38 N87-25608
Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801
Military man in space: A history of Air Force efforts to find a manned space mission
[AD-A178873] p 171 N87-25815
Space station systems: A bibliography with indexes (supplement 4)
[NASA-SP-7056(04)] p 4 N87-26073
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-181165] p 141 N87-26092
Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89088] p 37 N87-26095
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4081] p 53 N87-26098
Hydrogen/oxygen economy for the space station
p 98 N87-26130
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 98 N87-26133
Water-propellant resistojets for man-tended platforms
[NASA-TM-100110] p 98 N87-26135
Space station electrical power system
[NASA-TM-100140] p 80 N87-26144
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424
Space station power system p 80 N87-26447
Control engineering tasks in the framework of the Columbus program
[MBB-UR-E-912/86] p 158 N87-26842
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-26938
Military space station implications
[AD-A180831] p 172 N87-26964
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180342] p 53 N87-27405
Space suit extravehicular hazards protection development
[NASA-TM-89055] p 53 N87-27407
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412
MI department head on orbital power plants
p 158 N87-27660
Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-28581
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-28582
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179167] p 4 N87-28583
Data management system architecture options for space stations -- Columbus project
[SES/DNP/TR/002/86] p 115 N87-28585
Study of data management system architecture options for space station -- Columbus project
[MATRA-RF/176/0932-686-1] p 115 N87-28586
Space station power semiconductor package
[NASA-CR-180829] p 81 N87-28825
The space station power system p 81 N87-28880
High power solar array technologies -- Columbus space station p 82 N87-28976
Organic Rankine cycle power conversion systems for space applications p 159 N87-28988
Automated Subsystem Control for Life Support System (ASCLSS)
[NASA-CR-172003] p 53 N87-29117
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89286] p 116 N87-29124
Engineering graphics and image processing at Langley Research Center p 10 N87-29129
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89288] p 116 N87-29144
MAX: A space station computer option
p 116 N87-29148
Information network architectures p 116 N87-29149
Video image processing p 116 N87-29150
Fiber optics wavelength division multiplexing(components) p 117 N87-29151
Fiber optic data systems p 117 N87-29152
Advanced local area network concepts
p 117 N87-29153
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155
User interface and payload command and control
p 73 N87-29162
User data management p 4 N87-29163
Advanced software tools space station focused technology p 5 N87-29164
Network operating system p 117 N87-29166
Network operating system focus technology
p 117 N87-29167
KSC Space Station Operations Language (SSOL)
p 138 N87-29169
Optimizing experimental programs in operational planning of research carried out from spacecraft
p 160 N87-29583
Vibrations and structureborne noise in space station
[NASA-CR-181301] p 39 N87-29850
Space Station end effector strategy study
[NASA-TM-100486] p 103 N87-29865
Space Station based options for orbiter docking/berthing p 139 N87-29877
An electromechanical attenuator/actuator for Space Station docking p 139 N87-29879
Space Station alpha joint bearing p 68 N87-29892
JPL future missions and energy storage technology implications p 84 N87-29917
Application of advanced flywheel technology for energy storage on space station p 74 N87-29923
National Aeronautics and Space Administration
p 172 N87-29939

NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988
[GPO-73-245] p 172 N87-30221

SPACE SUITS
A comparison between space suited and unsuited reach envelopes p 47 A87-33013
Space suit reach and strength envelope considerations
[SAE PAPER 860850] p 49 A87-38737
Desirability of arms-in capability in space suits
[SAE PAPER 860851] p 49 A87-38738
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
An evaluation of advanced extravehicular crew enclosures
[SAE PAPER 861009] p 134 A87-38781
Human factors in space station architecture 2. EVA access facility: A comparative analysis of 4 concepts for on-orbit space suit servicing
[NASA-TM-86856] p 52 N87-24084
Space suit extravehicular hazards protection development
[NASA-TM-88055] p 53 N87-27407

SPACE TOOLS
End effector development study, volume 1 -- in-orbit servicing
[FOK-TR-R-86-081-VOL-1] p 102 N87-25338

SPACE TRANSPORTATION
National space transportation studies
[SAE PAPER 861681] p 160 A87-32580
On the dynamical stability of the space 'monorail'
p 148 A87-34047
The SERVICE concept p 134 A87-38382
Trends in space transportation p 168 A87-41572
The Soviet space shuttle programme
p 153 A87-47302
Leadership in space transportation
p 170 A87-53688
The astronaut and the robot - Short- and long-term scenarios for space technology p 101 A87-53691
National Aeronautics and Space Administration
p 172 N87-30220

SPACE TRANSPORTATION SYSTEM
System and operation analyses of OTV Network - A new space transportation concept p 145 A87-32475
System level verification applying the Space Shuttle experience to the Space Station
[AAS PAPER 86-001] p 55 A87-32727
Liquid propulsion technology for expendable and STS launch vehicle transfer stages
[AIAA PAPER 87-1804] p 82 A87-45311
NERVA derived nuclear orbit transfer system
[AIAA PAPER 87-2156] p 92 A87-45429
Space operations: NASA's use of information technology. Report to the Chairman, Committee on Science, Space and Technology
[GAO/IMTEC-87-20] p 137 N87-22551
Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-73-418] p 171 N87-22560
National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240
Military man in space: A history of Air Force efforts to find a manned space mission
[AD-A178873] p 171 N87-25815
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-26693
NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1989
[GPO-73-245] p 172 N87-30221

SPACEBORNE ASTRONOMY
The Signe 3 gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-38443
The Space Station - Uses and users
p 151 A87-40513
'HEXE' - X-ray observatory in space
p 155 A87-53568

SPACEBORNE EXPERIMENTS
Gas and water recycling system for IOC vivarium experiments -- Initial Operational Capacity
p 45 A87-32457
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
Development of exposed deck of Japanese experiment module p 145 A87-32532
Solar concentrator system for experiments in the Space Station p 146 A87-32535
Advanced technology experiment onboard space platform p 122 A87-32538
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540
Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34208
Thermal design of the ACCESS erectable space truss
p 42 A87-34489
Space Station - Opportunities for the life sciences
p 122 A87-34871
Status of the RITA - Experiment on EURECA -- Radio Frequency Ion Thruster Assembly
[AIAA PAPER 87-0988] p 123 A87-38002
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-210] p 89 A87-38568
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-38740
Life Support Subsystem concepts for botanical experiments of long duration
[SAE PAPER 860967] p 49 A87-38748
Life Sciences Research Facility automation requirements and concepts for the Space Station
[SAE PAPER 860970] p 50 A87-38752
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-38757
On-orbit cryogenic fluid management experimental data requirements using reference fluids
[AIAA PAPER 87-1558] p 80 A87-44832
Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2185] p 153 A87-48581
Ram ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51713
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002
Human capabilities in space
[AAS PAPER 86-114] p 165 A87-53089
Microgravity experiments onboard Eureca
p 156 A87-53654
From Eureca-A to Eureca-B p 157 A87-53816
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
Space station experiment definition: Long-term cryogenic fluid storage
[NASA-CR-4072] p 97 N87-24841
Ideas for educational physics experiments in space
p 130 N87-26033
Botanical payloads for platforms and space stations
[MBB-UR-E-921/86] p 158 N87-25340
Review of Low Earth Orbital (LEO) flight experiments
p 131 N87-28174
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements
p 108 N87-28175
Mass spectrometers and atomic oxygen
p 141 N87-28176
Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment
p 108 N87-28177
NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-28202
Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-28207
Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-28703
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 100 N87-28880
Test results from the solar array flight experiment
p 83 N87-29010

SPACEBORNE TELESCOPES
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222
Measuring thermal expansion in large composite structures -- for spaceborne telescopes
p 20 A87-38812
Optical arrays for future astronomical telescopes in space p 126 A87-44633
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445
An astrometric facility for planetary detection on the Space Station p 127 A87-50780
An astrometric facility for planetary detection on the space station
[NASA-TM-89438] p 128 N87-20941
Astronomic Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description
[NASA-TM-89429-VOL-2] p 129 N87-22570
Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary
[NASA-TM-89429-VOL-1] p 129 N87-22571

SPACECRAFT ANTENNAS
Robust controller synthesis for a large flexible space antenna p 64 A87-32235
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0901] p 19 A87-34701
Composite space antenna structures - Properties and environmental effects p 20 A87-38810
The evolution of the geostationary platform concept
p 125 A87-43154
Antenna systems and RF coverage for the Space Station p 2 A87-45523
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327
On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2458] p 61 A87-50505
Large space antennas: A systems analysis case history
[NASA-TM-89072] p 26 N87-20352
Stress and deformation analysis of lightweight composite structures -- space antennas
[MBB-UD-488/86] p 30 N87-22269
Robust control for large space antennas
p 87 N87-24489
Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24508

SPACECRAFT CABIN ATMOSPHERES
An evolutionary approach to the development of a CELSS based air revitalization system
[SAE PAPER 860969] p 49 A87-38750
An advanced carbon reactor subsystem for carbon dioxide reduction
[SAE PAPER 860995] p 51 A87-38772

SPACECRAFT CABIN SIMULATORS
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53879

SPACECRAFT CABINS
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724

SPACECRAFT CHARGING
Spacecraft dielectric material properties and spacecraft charging -- Book p 106 A87-33100
Potential modulation on the SCATHA spacecraft
p 138 A87-34480
Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41611
Ram ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51713
Potential modulations on SCATHA (Spacecraft Charging At High Altitudes) spacecraft
[AD-A176815] p 140 N87-21024
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-28837
The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-28842
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved
p 142 N87-28849
Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-28852
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit
p 158 N87-28853
Radiation charging and breakdown of insulators
p 143 N87-28854
Electrostatic immunity of geostationary satellites
p 143 N87-28857
Surface modification to minimize the electrostatic charging of Kapton in the space environment
p 87 N87-28858
Automatic charge control system for geosynchronous satellites p 87 N87-28860
Thick dielectric charging on high altitude spacecraft
p 87 N87-28861
Documentation for the SHADO particle wake routine
[AD-A181531] p 131 N87-28867
Stopping differential charging of solar arrays
p 83 N87-28894

SPACECRAFT COMMUNICATION
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31482
Japanese experiment module data management and communication system p 147 A87-32542
Space Station communications and tracking system
p 134 A87-37297

Star topology spacecraft data bus p 112 A87-37431
Communication and Data Management Systems for an orbiting platform p 112 A87-40359
On-board communications, including EVA p 85 A87-40360
FDMA system design and analysis for Space Station p 85 A87-45483
Feasibility study on 8PSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel p 113 A87-45485
Multiple beam phased array for Space Station Control Zone Communications p 85 A87-45519
End-to-end communications for Space Station p 85 A87-45522
Space Station multiple access communications system p 86 A87-45524
Japanese customer needs for Space Station [AIAA PAPER 87-2193] p 153 A87-48580
Data capture and processing — for Space Station [AIAA PAPER 87-2203] p 113 A87-48588
The Consultative Committee for Space Data Systems Standards program [AIAA PAPER 87-2204] p 113 A87-48589
Data management standards for space information systems [AIAA PAPER 87-2205] p 113 A87-48590
Space Station Information System integrated communications concept [AIAA PAPER 87-2228] p 114 A87-48606
Space Station Information System requirements for integrated communications [AIAA PAPER 87-2229] p 114 A87-48607
Measurement apparatus and procedure for the determination of surface emissivities [NASA-CASE-LAR-13455-1] p 29 N87-21208
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications [AGARD-CP-406] p 142 N87-26937
User interface and payload command and control p 73 N87-29162

SPACECRAFT COMPONENTS
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings p 167 A87-38576
Materials for space applications p 108 A87-44741
Dynamic analysis of the flexible boom in the N-ROSS satellite [AD-A181488] p 72 N87-26866
Computer simulation of a rotational single-element flexible spacecraft boom [AD-A181798] p 103 N87-26888
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment [AD-A182931] p 110 N87-29709

SPACECRAFT CONFIGURATIONS
Mechanical design of the Eurostar platform p 149 A87-34874
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 p 123 A87-38587
Mass property estimation for control of asymmetrical satellites p 63 A87-52988
Modal testing of the Olympus development model stowed solar array p 27 N87-20088
Variable structure control system manoeuvering of spacecraft p 64 N87-21689
Impact of space station appendage vibrations on the pointing performance of gimballed payloads p 32 N87-22733
Preliminary evaluation of a reaction control system for the space station p 67 N87-22736
The space station power system p 81 N87-28080
Status of space station power system p 84 N87-29815

SPACECRAFT CONSTRUCTION MATERIALS
A space debris simulation facility for spacecraft materials evaluation p 11 A87-32058
The Vanderbilt University neutral O-beam facility p 105 A87-32059
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 105 A87-32060
Selected materials issues associated with Space Station p 105 A87-32061
Spacecraft dielectric material properties and spacecraft charging — Book p 105 A87-33100
Computerized aerospace materials data; Proceedings of the Workshop on Computerized Property Materials and Design Data for the Aerospace Industry, El Segundo, CA, June 23-25, 1986 p 111 A87-35252
Comparison of satellite support structure aluminum versus graphite epoxy [SAWE PAPER 1692] p 20 A87-38279
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings p 167 A87-38576
Effect of long-term exposure to LEO space environment on spacecraft materials p 108 A87-39428
Microcrack resistant structural composite tubes for space applications p 108 A87-41022
The definition of the low earth orbital environment and its effect on thermal control materials [AIAA PAPER 87-1599] p 43 A87-43103
Materials for space applications p 108 A87-44741
Development of full scale deployable CFRP truss for space structure p 25 A87-51783
Future trends in spacecraft design and qualification p 2 N87-20356
Oxidation protection coatings for polymers [NASA-CASE-LEW-14072-3] p 107 N87-23736
Fiber composites in satellites [MBB-UD-492/86] p 107 N87-25430
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets p 45 N87-26192
An evaluation of candidate oxidation resistant materials p 110 N87-26203
Radiation charging and breakdown of insulators p 143 N87-26954

SPACECRAFT CONTAMINATION
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32346
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration [SAE PAPER 860916] p 47 A87-38708
External contamination environment of Space Station Customer Servicing Facility [AIAA PAPER 87-1623] p 52 A87-43122
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53879
Resistojet plume and induced environment analysis [NASA-TM-88957] p 95 N87-24538
Contamination assessment for OSSA space station IOC payloads [NASA-CR-181165] p 141 N87-26082
Contamination assessment for OSSA space station IOC payloads [NASA-CR-4091] p 53 N87-26086

SPACECRAFT CONTROL
Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 89 A87-31480
Expert systems in space p 111 A87-32075
Robust controller design using frequency domain constraints p 11 A87-32229
A review of modelling techniques for the open and closed-loop dynamics of large space systems p 12 A87-32337
Local control for large space structures p 54 A87-32440
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel p 55 A87-32448
Control of a flexible space manipulator p 99 A87-32449
Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 p 55 A87-32726
Low-authority control through passive damping [AAS PAPER 86-004] p 55 A87-32730
A highly adaptable steering/selection procedure for combined CMG/RCS spacecraft control [AAS PAPER 86-009] p 56 A87-32741
Aeroassist flight experiment guidance, navigation and control [AAS PAPER 86-042] p 132 A87-32744
System architecture for the telerobotic work system [AAS PAPER 86-044] p 99 A87-32746
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure [AIAA PAPER 87-0885] p 16 A87-33680
Adaptive tracking of dynamical model by uncertain nonlinearizable spacecraft [AIAA PAPER 87-0940] p 57 A87-33739
On a balanced passive damping and active vibration suppression of large space structures [AIAA PAPER 87-0901] p 19 A87-34701
Variable structure controller design for spacecraft nutation damping p 58 A87-38958
Deployment dynamics of space structures p 58 A87-40074
Interdisciplinary analysis procedures in the modeling and control of large space-based structures p 22 A87-42676
Actuators for actively controlled space structures p 59 A87-42816
Robust nonlinear attitude control of flexible spacecraft p 60 A87-46273
AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volumes 1 & 2 p 60 A87-50401
Construction of positive real compensation for LSS control — applied to Large Space Structure model [AIAA PAPER 87-2238] p 60 A87-50404
Low-authority control of large space structures by using tendon control system [AIAA PAPER 87-2249] p 60 A87-50413
Robust control of a large space antenna [AIAA PAPER 87-2253] p 86 A87-50417
A laboratory simulation of flexible spacecraft control [AIAA PAPER 87-2325] p 24 A87-50446
An analytical and experimental investigation of output feedback vs. linear quadratic regulator — for large space structures [AIAA PAPER 87-2380] p 61 A87-50474
Comparison of different attitude control schemes for large communications satellites [AIAA PAPER 87-2381] p 61 A87-50475
Control/dynamics simulation for preliminary Space Station design [AIAA PAPER 87-2441] p 61 A87-50486
Practical issues in computation of optimal, distributed control of flexible structures [AIAA PAPER 87-2481] p 25 A87-50507
Adaptive momentum management for the dual keel Space Station [AIAA PAPER 87-2586] p 62 A87-50558
The dynamics and control of the Space Station polar platform [AIAA PAPER 87-2600] p 62 A87-50562
Mass property estimation for control of asymmetrical satellites p 63 A87-52988
Propellant tank resupply system [AD-D012558] p 93 N87-20375
Space station momentum management p 64 N87-20688
Space station control moment gyro control p 64 N87-20689
Aero-Assisted Orbital Transfer Vehicle (AOTV) p 3 N87-20692
Variable structure control system maneuvering of spacecraft p 64 N87-21689
Structural Dynamics and Control Interaction of Flexible Structures [NASA-CP-2467-PT-1] p 65 N87-22702
Status of the Mast experiment p 30 N87-22703
Microprocessor controlled proof-mass actuator p 65 N87-22708
Considerations in the design and development of a space station scale model p 9 N87-22711
Optimum mix of passive and active control of space structures p 65 N87-22714
Status report and preliminary results of the spacecraft control laboratory experiment p 66 N87-22717
Precision pointing and control of flexible spacecraft p 66 N87-22723
Control of flexible structures and the research community p 66 N87-22732
Moving-bank multiple model adaptive estimation applied to flexible spacestructure control [AD-A178870] p 68 N87-22761
NASA/DOD Control/Structures Interaction Technology, 1986 [NASA-CP-2447-PT-2] p 34 N87-24495
Large spacecraft pointing and shape control p 69 N87-24496
Robust control for large space antennas p 87 N87-24499
Large space systems technology and requirements p 3 N87-24500
Controls-structures-electromagnetics interaction program p 69 N87-24502
Application of physical parameter identification to finite-element models p 34 N87-24505
COFS 3 multibody dynamics and control technology p 69 N87-24506
Control technology overview in CSI p 69 N87-24507
Structural control by the use of piezoelectric active members p 69 N87-24509
Ground test of large flexible structures p 34 N87-24510

Slew maneuvers on the SCOLE Laboratory Facility
p 69 N87-24511

Research in slewing and tracking control
p 70 N87-24512

Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180391] p 70 N87-24513

Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354

The effects of structural perturbations on decoupled control -- spacecraft p 35 N87-25359

Automatic docking maneuver and attitude control s ystem p 71 N87-25385

Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89266] p 118 N87-29144

SPACECRAFT DESIGN

Space launcher upper stages - Design for mission versatility and/or orbital operation p 132 A87-32474

Design of a polar platform with an earth observation payload p 122 A87-32538

Concept design and cost estimation of a free-flying space platform p 148 A87-32539

Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33810

Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0826] p 14 A87-33813

Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737

Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724

Concepts for the evolution of the Space Station Program
[SAE PAPER 860972] p 120 A87-38754

Evaluation of Space Station thermal control techniques
[SAE PAPER 860999] p 42 A87-38775

Application of reanalysis techniques in dynamic analysis of spacecraft structures p 21 A87-38824

Advanced technology for the Space Station
p 120 A87-40353

An integrated approach to spacecraft design for robotic servicing
[AIAA PAPER 87-1672] p 100 A87-41152

Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1505] p 180 A87-43031

Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1628] p 44 A87-43128

The Earth Observing System (EOS) synthetic aperture radar (SAR) p 128 A87-44187

Liquid propulsion technology for expendable and STS launch vehicle transfer stages
[AIAA PAPER 87-1834] p 92 A87-45311

An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46790

Space Station - The next logical step
p 189 A87-47888

Square root state estimator for large space structures
[AIAA PAPER 87-2389] p 24 A87-50473

Control/dynamics simulation for preliminary Space Station design
[AIAA PAPER 87-2841] p 61 A87-50488

Structure and design of spacecraft -- Russian book
p 155 A87-51870

From Eureca-A to Eureca-B p 155 A87-53816

Future trends in spacecraft design and qualification
p 2 N87-20356

Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357

Dynamic modeling and optimal control design for large flexible space structures p 28 N87-20359

Effect of modal damping in modal synthesis of spacecraft structures p 26 N87-20362

Benefits of passive damping as applied to active control of large space structures p 63 N87-20371

Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations
[NASA-CP-2460] p 64 N87-20885

Orbital transfer vehicle concept definition and system analysis study. Volume 1A: Executive summary. Phase 2
[NASA-CR-179055] p 181 N87-21018

The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178192] p 9 N87-21095

Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21898

A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731

Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-84/85] p 35 N87-24516

Assessment of space station power system
[ATES-AN-86/486] p 79 N87-24530

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5). Volume 1A, part 1: Executive summary, phase 1
[NASA-CR-179139] p 97 N87-26062

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2
[NASA-CR-179140] p 3 N87-26063

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 3: Cost estimates and work breakdown structure/dictionary, phase 1 and 2
[NASA-CR-179144] p 3 N87-26064

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 2: Supporting research and technology report, phase 1 and 2
[NASA-CR-179143] p 3 N87-26065

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results
[NASA-CR-179142] p 4 N87-26067

Development of experimental/analytical concepts for structural design verification -- spacecraft structures
[ESA-CR(P)-2340] p 36 N87-26075

Design and demonstrate the performance of cryogenic components representative of space vehicles: Start basket liquid acquisition device performance analysis
[NASA-CR-179128] p 97 N87-26081

USSR Report: Space
[JPRS-USP-86-004] p 159 N87-27687

Pravda commentary, photos of Mir orbital station
p 158 N87-27688

Status of space station power system
p 84 N87-29915

SPACECRAFT DOCKING

Rendezvous and docking tracker
[AAS PAPER 86-014] p 133 A87-32733

Laser docking system flight experiment
[AAS PAPER 86-043] p 89 A87-32745

Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-49158

Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54189

Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22709

Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2
[LP-RP-AI-204-VOL-2] p 69 N87-24480

Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24481

Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Docking-undocking phase analysis
[LP-RP-AI-204-VOL-1] p 70 N87-24514

Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-89221] p 137 N87-25339

Automatic docking maneuver and attitude control s ystem p 71 N87-25385

Preloadable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 161 N87-25582

Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801

Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-518/86] p 136 N87-26588

The preloadable vector sensitive latch for orbital docking/berthing p 162 N87-29876

Space Station based options for orbiter docking/berthing p 138 N87-29877

An electromechanical attenuator/actuator for Space Station docking p 139 N87-29878

SPACECRAFT ELECTRONIC EQUIPMENT

An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579

SPACECRAFT ENVIRONMENTS

ISOKIN - A quantitative model of the kinesthetic aspects of spatial habitability p 162 A87-33002

Human performance in space p 162 A87-33021

Human factors standards for space habitation
p 162 A87-33022

Living in space: A handbook for space travellers
p 162 A87-33475

Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 46 A87-38729

Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 46 A87-38730

Environmental Control Life Support for the Space Station
[SAE PAPER 860944] p 46 A87-38731

Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 46 A87-38733

Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 50 A87-38762

A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 860984] p 50 A87-38763

Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860985] p 50 A87-38764

Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860994] p 51 A87-38771

Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 861007] p 52 A87-38779

Effect of long-term exposure to LEO space environment on spacecraft materials p 106 A87-39426

Spacecraft environment interaction investigation
[AD-A179183] p 140 N87-23878

Resistojet plume and induced environment analysis
[NASA-TM-88857] p 89 N87-24536

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181009] p 45 N87-26072

Active vibration control in microgravity environment
p 72 N87-26700

Space stable thermal control coatings
[AD-A182798] p 110 N87-28084

Space station propulsion-ECLSS interaction study
[NASA-CR-175080] p 54 N87-29594

A microgravity isolation mount p 161 N87-29881

SPACECRAFT EQUIPMENT

Development of fluid loop system for spacecraft
p 144 A87-32370

A master-slave manipulator system for space use
p 147 A87-32546

SPACECRAFT GLOW

Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26200

SPACECRAFT GUIDANCE

Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 p 56 A87-32726

System level verification applying the Space Shuttle experience to the Space Station
[AAS PAPER 86-001] p 55 A87-32727

Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744

SPACECRAFT INSTRUMENTS

Fiber-optic monitors for space structures
p 11 A87-31505

Design of an advanced two-phase capillary cold plate
[SAE PAPER 861629] p 41 A87-32583

Earth resources instrumentation for the Space Station Polar Platform p 129 A87-44184

Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS
p 128 A87-44186

Space Station tracking subsystem sensor evaluation
p 85 A87-45520

Operational instruments on the Space Station-Polar Platforms - Contributions by NOAA and the international community p 127 A87-53148

The GDR and the Soviet space program - The optical instrument sector of the GDR contributions
p 156 A87-53558

SPACECRAFT LAUNCHING

Analysis of Intelsat V flight data
[AIAA PAPER 87-0784] p 16 A87-33879

SPACECRAFT LUBRICATION

Space Station lubrication considerations
p 104 N87-29879

SPACECRAFT MAINTENANCE

Refueling satellites in space - The OSCRS program
[SAE PAPER 861787] p 88 A87-32845

A maintenance work station for Space Station
[SAE PAPER 860933] p 167 A87-38723

Concepts for space maintenance of OTV engines
p 133 A87-46000

Robotic telepresence p 100 A87-46704

Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-26581

SPACECRAFT MANEUVERS

Orbital modifications using forced tether-length variations p 124 A87-40858

Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation
[AIAA PAPER 87-2021] p 92 A87-45380

Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-48156

Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2587] p 93 A87-49817

Equations of motion for maneuvering flexible spacecraft p 63 A87-52985

Variable structure control system maneuvering of spacecraft p 64 N87-21888

Dynamic finite element modeling of flexible structures
[AD-A177168] p 30 N87-22252

Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180808] p 71 N87-25352

Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25355

Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25358

Automatic docking maneuver and attitude control system p 71 N87-25385

SPACECRAFT MODELS

Prediction of random vibrational responses of a large spacecraft in acoustic environment by BLPF method p 144 A87-32334

A review of modelling techniques for the open and closed-loop dynamics of large space systems p 12 A87-32337

Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20089

Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 30 N87-22258

Considerations in the design and development of a space station scale model p 9 N87-22711

Maximum likelihood parameter identification of flexible spacecraft
[ETN-87-90235] p 28 N87-27705

Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary — laboratory test model
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707

Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report — laboratory test model
[ESA-CR(P)-2381-VOL-2] p 73 N87-27708

Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2381-VOL-4] p 73 N87-27709

SPACECRAFT MODULES

Thermal verification method for large sized spacecraft p 144 A87-32388

Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456

Status of Japanese Experiment Module design p 145 A87-32531

Development of exposed deck of Japanese experiment module p 145 A87-32532

Japanese experiment module data management and communication system p 147 A87-32542

Habitation module for the Space Station
[SAE PAPER 860928] p 163 A87-38718

Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 48 A87-38730

Special considerations in outfitting a space station module for scientific use
[SAE PAPER 860958] p 164 A87-38741

Habitability issues for the Science Laboratory Module
[SAE PAPER 860971] p 50 A87-38753

Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570

Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results
[AIAA PAPER 87-2157] p 160 A87-45441

Columbus pressurized modules p 153 A87-48845

New power processor interfaces MMS power module outputs — Multimission Modular Spacecraft p 77 A87-48284

Space station group activities habitability module study
[NASA-CR-4010] p 165 N87-21585

SPACECRAFT MOTION

Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33887

The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0891] p 58 A87-38844

Effect of crew motions on the spatial position of a spacecraft p 152 A87-41954

Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2588] p 62 A87-50558

The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50562

Crew activity and motion effects on the space station p 165 N87-22744

Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752

Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801

Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-179148] p 130 N87-26083

SPACECRAFT ORBITS

Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment p 148 A87-34207

A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179108] p 161 N87-23877

Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182569] p 81 N87-29188

SPACECRAFT PERFORMANCE

Analysis of Intelsat V flight data
[AIAA PAPER 87-0794] p 16 A87-33879

Performance of an SP-100/pulsed electrothermal thruster orbit transfer vehicle
[AIAA PAPER 87-2027] p 77 A87-45383

SPOT solar array in-orbit deployment results evaluation p 82 N87-29886

SPACECRAFT POWER SUPPLIES

Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32398

ERATO orbital transfer vehicle with electronuclear power Study of the associated electronuclear generator p 75 A87-36844

Manned spacecraft electrical power systems p 75 A87-37291

Tether power supplies exploiting the characteristics of space
[AAS PAPER 86-227] p 123 A87-38571

Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572

Resistojet control and power for high frequency ac buses
[AIAA PAPER 87-0994] p 58 A87-41100

The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42585

The benefit of phase change thermal storage for spacecraft thermal management
[AIAA PAPER 87-1482] p 43 A87-43014

Liquid droplet radiator development status — waste heat rejection devices for future space vehicles
[AIAA PAPER 87-1537] p 43 A87-43059

New power processor interfaces MMS power module outputs — Multimission Modular Spacecraft p 77 A87-48284

Use of lightweight composites for GAS payload structures p 25 N87-20307

Liquid droplet radiator development status
[NASA-TM-88852] p 44 N87-20353

Resistojet control and power for high frequency ac buses
[NASA-TM-88980] p 63 N87-20477

Structural concepts for large solar concentrators
[NASA-CR-4075] p 65 N87-21994

Coaxial tube array space transmission line characterization
[NASA-TM-88894] p 98 N87-22003

EMC and power quality standards for 20-kHz power distribution
[NASA-TM-88905] p 78 N87-22004

Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-89886] p 79 N87-22174

Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88928] p 68 N87-23880

Assessment of space station power system
[ATES-AN-85/488] p 79 N87-24530

Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2318] p 79 N87-24533

Electrochemical processing of solid waste
[NASA-CR-181128] p 137 N87-25443

Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88295] p 79 N87-25838

Space station electrical power system
[NASA-TM-100140] p 80 N87-28144

An overview of photovoltaic applications in space p 80 N87-28414

Advanced photovoltaic solar array design assessment p 80 N87-28429

Space station power system p 80 N87-28447

Space station electrical power distribution analysis using a load flow approach p 80 N87-28889

Development of an alkaline fuel cell subsystem
[NASA-CR-172002] p 81 N87-29189

Space station power semiconductor package
[NASA-CR-180829] p 81 N87-29825

Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-29859

The space station power system p 81 N87-29860

Alternative power generation concepts for space p 81 N87-29861

AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits p 150 N87-29869

The high performance solar array GSR3 p 81 N87-29872

Improved solar generator technology for the EURECA low Earth orbit p 159 N87-29874

The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-29875

GaAs concentrator solar arrays p 82 N87-29877

The Fokker Strongback solar array p 82 N87-29879

MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-29880

Micrometeorite impact on solar panels — ESA telecommunication satellites p 82 N87-29881

Aerospatiale solar arrays, in orbit performance p 159 N87-29883

Organic Rankine cycle power conversion systems for space applications p 159 N87-29889

Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-29904

The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-29912

The liquid droplet radiator in space: A parametric approach
[AD-A182806] p 46 N87-29217

Application of advanced flywheel technology for energy storage on space station p 74 N87-29933

SPACECRAFT PROPULSION

Mechanical design of the Eurostar platform p 149 A87-34874

Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572

Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-38628

Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-38629

Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40510

1987 status report - United States Air Force electric propulsion research and development
[AIAA PAPER 87-1036] p 90 A87-41122

Concepts for space maintenance of OTV engines p 135 A87-41161

Thermal design of a large spacecraft propulsion system
[AIAA PAPER 87-1863] p 44 A87-45258

Performance of an SP-100/pulsed electrothermal thruster orbit transfer vehicle
[AIAA PAPER 87-2027] p 77 A87-45383

Ion thrusters advance p 93 A87-54198

Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54199

Propellant tank resupply system
[AD-D012558] p 93 N87-20075

Orbital transfer vehicle concept definition and system analysis study. Volume 1A: Executive summary. Phase 2
[NASA-CR-179055] p 161 N87-21018

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2
[NASA-CR-179140] p 3 N87-26063

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results
[NASA-CR-179142] p 4 N87-26067

Propulsion recommendations for space station free flying platforms p 98 N87-26129
Water-propellant resistojets for man-tended platforms [NASA-TM-100110] p 98 N87-26135

SPACECRAFT RADIATORS
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32348
A thermally-pumped heat transport system p 40 A87-32399
Environmental avoidance concepts for steerable Space Station radiators [SAE PAPER 861021] p 41 A87-32885
High capacity demonstration of honeycomb panel heat pipes [SAE PAPER 861033] p 41 A87-32888
Space station active thermal control system modeling [AIAA PAPER 87-1468] p 43 A87-43003
Liquid sheet radiator [AIAA PAPER 87-1525] p 43 A87-43048
Liquid droplet radiator development status -- waste heat rejection devices for future space vehicles [AIAA PAPER 87-1537] p 43 A87-43056
Liquid droplet radiator development status [NASA-TM-89852] p 44 N87-20353
The liquid droplet radiator in space: A parametric approach [AD-A180885] p 46 N87-26217

SPACECRAFT RECOVERY
The mission function control for deployment and retrieval of subsatellite [AIAA PAPER 87-2325] p 129 A87-50447

SPACECRAFT REENTRY
Nonequilibrium radiation during re-entry at 10 km/s [AIAA PAPER 87-1543] p 135 A87-43060

SPACECRAFT RELIABILITY
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 158 N87-20357

SPACECRAFT SHIELDING
Radiation shielding requirements on long-duration space missions [AD-A177512] p 140 N87-21881

SPACECRAFT STABILITY
A consideration to vibration control for a large space structures p 54 A87-32441
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Vibration control for a linked system of flexible structures p 55 A87-32444
The Softmounted Inertially Reacting Pointing System (SIRPNT) [AAS PAPER 86-007] p 58 A87-32732
Stability in the relative equilibrium positions of space stations at triangular libration points in the photogravitational three-body problem p 1 A87-33002
Vibration suppression using a constrained rate-feedback Threshold control strategy -- for large space structures [AIAA PAPER 87-0741] p 6 A87-33665
Modal analyses of dynamics of a deformable multibody spacecraft - The Space Station: A continuum approach [AIAA PAPER 87-0925] p 17 A87-33727
Tethered satellite program control strategy [AAS PAPER 86-221] p 123 A87-38570
Variable structure controller design for spacecraft nutation damping p 58 A87-38958
Active vibration control synthesis for the COFS-I - A classical approach -- Control of Flexible Structures experiment for NASA [AIAA PAPER 87-2322] p 23 A87-50443
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement p 94 N87-21147
A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 35 N87-25357

SPACECRAFT STRUCTURES
Transient dynamics of orbiting flexible structural members p 54 A87-32338
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32349
Critical length for stable elongated orbiting structures p 149 A87-32819
ASTROS - A multidisciplinary automated structural design tool [AIAA PAPER 87-0713] p 6 A87-33657
An equivalent continuum analysis procedure for Space Station lattice structures [AIAA PAPER 87-0724] p 13 A87-33664
Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Parts 2A & 2B p 15 A87-33654
Adaptive planar truss structures and their vibration characteristics [AIAA PAPER 87-0743] p 148 A87-33667
Effects of local vibrations on the dynamics of space truss structures [AIAA PAPER 87-0941] p 17 A87-33739
Comparison of the Craig-Bampton and residual flexibility methods of substructure representation p 19 A87-34510
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings p 167 A87-38576
Joint technology for graphite epoxy space structures p 20 A87-38600
Martin Marietta atomic oxygen beam facility p 139 A87-38822
A high flux pulsed source of energetic atomic oxygen -- for spacecraft materials ground testing p 139 A87-38823
Production of pulsed atomic oxygen beams via laser vaporization methods p 109 A87-38825
Structure-property relationships in polymer resistance to atomic oxygen p 108 A87-38842
Application of reanalysis techniques in dynamic analysis of spacecraft structures p 21 A87-38924
Dynamics of a multibody system with relative translation on curved, flexible tracks p 50 A87-40857
Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41670
Actuators for actively controlled space structures p 59 A87-42816
Radiation heat transfer calculations for space structures [AIAA PAPER 87-1522] p 44 A87-44830
Low-authority control of large space structures by using tendon control system [AIAA PAPER 87-2249] p 60 A87-50413
Structure and design of spacecraft -- Russian book p 155 A87-51670
Mechanical Qualification of Large Flexible Spacecraft Structures [AD-A175529] p 26 N87-20356
Future trends in spacecraft design and qualification p 2 N87-20358
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 68 N87-20360
Structural qualification of large spacecraft p 26 N87-20361
Effect of modal damping in modal synthesis of spacecraft structures p 26 N87-20362
Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363
Low frequency vibration testing on satellites p 27 N87-20364
Modal-survey testing for system identification and dynamic qualification of spacecraft structures p 27 N87-20366
Active structural controllers emulating structural elements by ICUs p 27 N87-20367
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20368
Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20369
Acoustic effects on the dynamic of lightweight structures p 28 N87-20372
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
Optimization of aerospace structures subjected to random vibration and fatigue constraints p 29 N87-20380
Stress and deformation analysis of lightweight composite structures -- space antennas [MBB-UD-480/86] p 30 N87-22203
Investigation for damping design and related nonlinear vibrations of spacecraft structures [EMSB-64/86] p 35 N87-24516
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities [AD-A180808] p 71 N87-25352
Development of experimental/analytical concepts for structural design verification -- spacecraft structures [ESA-CR(P)-2340] p 36 N87-26075
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts [NASA-CR-180817] p 38 N87-27260

SPACECRAFT TEMPERATURE
Thermal verification method for large sized spacecraft p 144 A87-32360
Development of fluid loop system for spacecraft p 144 A87-32370
Development status of a two-phase thermal management system for large spacecraft [SAE PAPER 861026] p 41 A87-32882
The capabilities of Eureca thermal control for future mission scenarios [SAE PAPER 860936] p 42 A87-38725
Infrared test technique validation on the Olympus satellite [SAE PAPER 860939] p 150 A87-38728
Quality monitoring in two-phase heat transport systems for large spacecraft [SAE PAPER 860959] p 42 A87-38743
Evaluation of Space Station thermal control techniques [SAE PAPER 860998] p 42 A87-38775
Thermal test results of the two-phase thermal bus technology demonstration loop [AIAA PAPER 87-1627] p 44 A87-43125
Radiation heat transfer calculations for space structures [AIAA PAPER 87-1522] p 44 A87-44830
Thermal design of a large spacecraft propulsion system [AIAA PAPER 87-1883] p 44 A87-45258
Development of an emulation-simulation thermal control model for space station application [NASA-CR-181059] p 45 N87-26072
Spacecraft ram glow and surface temperature p 10 N87-26208

SPACECRAFT TRACKING
Space Station communications and tracking system p 134 A87-37287
Space Station tracking subsystem sensor evaluation p 65 A87-49520
Research in slewing and tracking control p 70 N87-24812
Track and capture of the orbiter with the space station remote manipulator system [NASA-TM-89221] p 137 N87-25339
Integration of communications and tracking data processing simulation for space station p 115 N87-26880

SPACECRAFT TRAJECTORIES
Track and capture of the orbiter with the space station remote manipulator system [NASA-TM-89221] p 137 N87-25339
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities [AD-A180808] p 71 N87-25352

SPACECREWS
Living in space: A handbook for space travellers p 162 A87-33475
Effect of crew motions on the spatial position of a spacecraft p 152 A87-41054
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735
Crew activity and motion effects on the space station p 165 N87-22744
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replacement [AD-A179108] p 161 N87-23877

SPACELAB
The industrial use of Spacelab p 168 A87-42086
Evolution of data management systems from Spacelab to Columbus [AIAA PAPER 87-2227] p 154 A87-48826

SPACELAB PAYLOADS
Infra-red astronomy after IRAS p 127 A87-54187

SPACERS
Modal study of simple masts -- for space applications p 144 A87-32339

SPACETENNAS
Static shape control for flexible structures [SAE PAPER 861022] p 13 A87-32869
Integrated structural electromagnetic optimization of large space antenna reflectors [AIAA PAPER 87-0824] p 14 A87-33811
Quasi-static shape adjustment of a 15 meter diameter space antenna [AIAA PAPER 87-0930] p 15 A87-33833
Robust control of a large space antenna [AIAA PAPER 87-2253] p 68 A87-50417

SPACING
A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications [NASA-CR-177447] p 130 N87-25767

SPECIFICATIONS
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 60 N87-26424

SPECTRAL METHODS
Spectral factorization and homogenization methods for modeling and control of flexible structures [AD-A176728] p 35 N87-24517

SPECTRAL SENSITIVITY
Absolute indoor calibration of large area solar cells p 159 N87-29015
SPEECH RECOGNITION
Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 99 A87-31493
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity [AD-A178087] p 120 N87-22782
SPIN DYNAMICS
Dynamic analysis of the flexible boom in the N-ROSS satellite [AD-A181469] p 72 N87-26888
SPIN STABILIZATION
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial beams p 71 N87-25355
SPOT (FRENCH SATELLITE)
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
Remote sensing applications: Commercial issues and opportunities for space station — SPOT p 158 N87-20528
SPOT/MEGS design and flight results obtained — solar array drive (MEGS) p 103 N87-29889
SPRINGS (ELASTIC)
New time-domain identification technique — for vibrating structures p 58 A87-40889
STABILITY AUGMENTATION
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-33801
STANDARDS
Human factors standards for space habitation p 162 A87-33522
The Consultative Committee for Space Data Systems Standards program [AIAA PAPER 87-2204] p 113 A87-48589
STATE ESTIMATION
Single-mode projection filters for identification and state estimation of flexible structures [AIAA PAPER 87-2287] p 24 A87-50471
Square root state estimation for large space structures [AIAA PAPER 87-2289] p 24 A87-50473
A spline-based parameter and state estimation technique for static models of elastic surfaces [NASA-CR-180449] p 11 N87-30107
STATIC DEFORMATION
Analytical solutions for static elastic deformations of wire ropes [AIAA PAPER 87-0730] p 6 A87-33681
Optimum shape control of flexible beams by piezo-electric actuators [NASA-CR-181413] p 40 N87-26898
STATIC DISCHARGERS
Electrostatic immunity of geostationary satellites p 145 N87-26667
STATIC LOADS
Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20888
STATIC MODELS
A spline-based parameter and state estimation technique for static models of elastic surfaces [NASA-CR-180449] p 11 N87-30107
STEADY STATE
A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 26 N87-25357
STEERING
A highly adaptable steering/selection procedure for combined CMG/RCS spacecraft control [AAS PAPER 86-005] p 58 A87-32741
STELLAR MOTIONS
Astrometric Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description [NASA-TM-89420-VOL-2] p 129 N87-22570
Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary [NASA-TM-89420-VOL-1] p 129 N87-22571
STIFFNESS
Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22736
STIFFNESS MATRIX
Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714
A general method for dynamic analysis of structures overview p 31 N87-22707
STIRLING CYCLE
Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-38735
Survey of solar-dynamic space power - The Stirling option p 77 A87-42268
STOCHASTIC PROCESSES
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37683
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
STORAGE BATTERIES
Use of lightweight composites for GAS payload structures p 25 N87-20307
STORAGE STABILITY
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement p 94 N87-21147
STORAGE TANKS
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results [AIAA PAPER 87-2157] p 160 A87-45441
Advanced long term cryogenic storage systems p 94 N87-21142
Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21158
STRAIN ENERGY METHODS
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340
STRAIN MEASUREMENT
Fiber-optic monitors for space structures p 11 A87-21505
STRATEGY
Space Station end effector strategy study [NASA-TM-100483] p 103 N87-29560
STRESS ANALYSIS
Analytical solutions for static elastic deformations of wire ropes [AIAA PAPER 87-0730] p 6 A87-33681
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger [AIAA PAPER 87-1540] p 44 A87-44843
Stress and deformation analysis of lightweight composite structures — space antennas [MBB-UD-489/86] p 30 N87-22269
STRESSES
Preloaded space structural coupling joints [NASA-CASE-LAR-13489-1] p 38 N87-27713
STRUCTURAL ANALYSIS
Validation of large space structures by ground tests p 11 A87-32328
Development of exposed deck of Japanese experiment module p 145 A87-32532
Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 p 13 A87-33551
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts p 16 A87-35227
U.S. National Congress of Applied Mechanics, 10th, University of Texas, Austin, June 16-20, 1986, Proceedings [AD-A181682] p 1 A87-42551
Dynamic modeling and optimal control design for large flexible space structures p 29 N87-20886
OPUS: Optimal Projection for Uncertain Systems [AD-A178080] p 29 N87-21085
Modeling and control of flexible structures [AD-A177168] p 29 N87-21338
Structural concepts for large solar concentrators [NASA-CR-4075] p 65 N87-21884
Dynamic finite element modeling of flexible structures [AD-A177169] p 30 N87-22252
Status of the Mast experiment p 30 N87-22703
Identification of large space structures: A state-of-practice report p 31 N87-22705
Impact of space station appendage vibrations on the pointing performance of gimballed payloads p 32 N87-22733
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction p 9 N87-22735
Design, development and fabrication of a deployable/retractable truss beam model for large space structures application [NASA-CR-178287] p 35 N87-25349
Shape design sensitivity analysis and optimal design of structural systems [NASA-CR-181088] p 37 N87-26370
Dynamic analysis of the flexible boom in the N-ROSS satellite [AD-A181469] p 72 N87-26888
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures — spacecraft masts [NASA-CR-180517] p 38 N87-27300
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures [NASA-CR-4089] p 40 N87-28889
STRUCTURAL DESIGN
Structural design and component tests of large geostationary satellite bus p 144 A87-32535
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340
Integrated control/structure design and robustness [SAE PAPER 861621] p 8 A87-32857
ASTROS - A multidisciplinary automated structural design tool [AIAA PAPER 87-0713] p 6 A87-33567
Control augmented structural synthesis with transient response constraints [AIAA PAPER 87-0748] p 56 A87-33573
Simultaneous structure/control optimization of large flexible spacecraft [AIAA PAPER 87-0823] p 14 A87-33610
Design considerations for a one-kilometer antenna stick [AIAA PAPER 87-0871] p 15 A87-33635
Identification of the zero-g shape of a space beam [AIAA PAPER 87-0872] p 15 A87-33636
Structural and control optimization of space structures [AIAA PAPER 87-0939] p 17 A87-33737
Mechanical design of the Eurostar platform p 148 A87-34874
Structure and design of spacecraft — Russian book p 156 A87-51670
Space station electric power system requirements and design [NASA-TM-89888] p 69 N87-22001
Integrated control/structure design and robustness p 65 N87-22880
Investigation for damping design and related nonlinear vibrations of spacecraft structures [EMSB-84/85] p 35 N87-24516
The Folder Strongback solar array p 62 N87-23879
STRUCTURAL DESIGN CRITERIA
Structural optimization with frequency constraints [AIAA PAPER 87-0767] p 13 A87-33583
Comparison of satellite support structure aluminum versus graphite epoxy [SAWE PAPER 1682] p 20 A87-38279
Gradient-based combined structural and control optimization p 21 A87-40858
A basis change strategy for the reduced gradient method and the optimum design of large structures p 23 A87-48841
Advanced EVA system design requirements study: EVAS/space station system interface requirements [NASA-CR-171891] p 120 N87-20031
The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary [NASA-CR-178276] p 8 N87-21820
Space station structures and dynamics test program p 30 N87-22751
Development of experimental/analytical concepts for structural design verification — spacecraft structures [ESA-CR(P)-2340] p 39 N87-28075
Design of a robust fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-28838
STRUCTURAL ENGINEERING
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32541
Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Parts 2A & 2B p 15 A87-33604
STRUCTURAL FAILURE
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37683
STRUCTURAL STABILITY
Transient dynamics of orbiting flexible structural members p 54 A87-32555
Modeling, stabilization and control of serially connected beams p 21 A87-41052
Dynamic and thermal effects in very large space structures p 25 N87-20347
Structural control by the use of piezoelectric active members p 69 N87-24039
Ground test of large flexible structures p 34 N87-24519
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures — spacecraft masts [NASA-CR-180517] p 38 N87-27300
STRUCTURAL VIBRATION
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32120
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLFF method p 144 A87-32534
A consideration to vibration control for a large space structures p 54 A87-32441

Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33687
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0803] p 17 A87-33712
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0805] p 57 A87-33714
Localization of vibrations in large space reflectors
[AIAA PAPER 87-0846] p 18 A87-33745
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0858] p 18 A87-33751
Control of flexible structures by applied thermal gradients p 21 A87-36543
New time-domain identification technique -- for vibrating structures p 58 A87-40869
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2249] p 60 A87-50413
Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2250] p 60 A87-50414
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 60 A87-50415
Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2589] p 62 A87-50681
Identification of large space structures - A factorization approach p 25 A87-52968
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 88 N87-20330
Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363
Low frequency vibration testing on satellites p 27 N87-20364
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371
Multi-axis vibration tests on spacecraft using hydraulic exciters p 6 N87-20373
Some problems in the control of large space structures
[AD-A178690] p 70 N87-25350
Vibrations and structureborne noise in space station
[NASA-CR-181201] p 33 N87-26020
STRUTS
Design, construction, and utilization of a space station assembled from 5-meter erectable struts p 34 N87-24801
SUBSTRUCTURES
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 6 A87-33680
Comparison of the Craig-Bampton and residual flexibility methods of substructure representation p 19 A87-34515
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures -- spacecraft masts
[NASA-CR-180917] p 38 N87-27380
SUPERCRITICAL FLUIDS
Supercritical water oxidation - Concept analysis for evolutionary Space Station application
[SAE PAPER 860993] p 51 A87-38770
SUPERFLUIDITY
Transferring superfluid helium in space p 88 A87-34712
Superfluid helium on orbit transfer (SHOOT) p 85 N87-21151
SUPERHIGH FREQUENCIES
On-board K- and S-band multi-beam antennas p 88 A87-46201
SUPERSONIC FLUTTER
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 169 A87-25308
SUPPLYING
Operation of the orbital spacecraft consumables resupply system (OSCRS) at the Space Station
[AIAA PAPER 87-1789] p 135 A87-45162
SUPPORT SYSTEMS
The Space Station software support environment - Not just what, but why
[AIAA PAPER 87-2203] p 114 A87-48823
SUPPORTS
A microgravity isolation mount p 181 N87-29891
SURFACE DISTORTION
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0889] p 15 A87-33633
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021
SURFACE GEOMETRY
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0889] p 15 A87-33633
SURFACE REACTIONS
Martin Marietta atomic oxygen beam facility p 139 A87-38622
Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38625
Proceedings of the NASA Workshop on Atomic Oxygen Effects -- low earth orbital environment
[NASA-CR-181163] p 141 N87-28173
Review of Low Earth Orbital (LEO) flight experiments p 131 N87-28174
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements p 108 N87-28175
Mass spectrometers and atomic oxygen p 141 N87-28176
Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment p 108 N87-28177
O-atom degradation mechanisms of materials p 141 N87-28178
Product energy distributions and energy partitioning in O atom reactions on surfaces p 108 N87-28180
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-28181
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules p 108 N87-28182
Dynamics of atom-surface interactions p 141 N87-28183
Laboratory studies of atomic oxygen reactions with solids p 4 N87-28185
Pulsed source of energetic atomic oxygen p 109 N87-28189
Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-28187
Chemical interactions in Low Earth Orbit (LEO) p 109 N87-28188
Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams p 109 N87-28200
Potential surfaces for O atom-polymer reactions p 109 N87-28201
NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-28202
Spacecraft ram glow and surface temperature p 10 N87-28205
Comments on the interaction of materials with atomic oxygen p 110 N87-28209
Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-28207
SURFACE TEMPERATURE
Spacecraft ram glow and surface temperature p 10 N87-28205
SWATH WIDTH
Summary of recent SAR instrument studies p 159 N87-27605
SWITCHING CIRCUITS
Power management equipment for space applications
[SAE PAPER 861021] p 74 A87-32576
Space station power semiconductor package
[NASA-CR-180829] p 81 N87-28025
SYNCHRONOUS PLATFORMS
Geostationary platforms - An international perspective p 121 A87-32258
Communication missions for geostationary platforms p 84 A87-34797
Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 129 N87-26825
Panel report on new approaches to calibration and validation -- Columbus polar platforms p 157 N87-26858
SYNCHRONOUS SATELLITES
Structural design and component tests of large geostationary satellite bus p 144 A87-32235
The evolution of the geostationary platform concept p 125 A87-43154
SYNTHETIC APERTURE RADAR
Carbon fibre slotted waveguide arrays p 86 A87-41302
The Earth Observing System (EOS) synthetic aperture radar (SAR) p 128 A87-44187
Summary of recent SAR instrument studies p 159 N87-27605
SYSTEM IDENTIFICATION
MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32539
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33670
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures p 21 A87-40075
Identification of large space structures - A factorization approach p 25 A87-52968
Modal-survey testing for system identification and dynamic qualification of spacecraft structures p 27 N87-20365
Identification of large space structures: A state-of-practice report p 31 N87-22705
SYSTEMS ANALYSIS
System and operation analyses of CITV Network - A new space transportation concept p 145 A87-32475
Large space antennas: A systems analysis case history
[NASA-TM-86072] p 26 N87-20352
Space station structures and dynamics test program
[NASA-TP-2710] p 28 N87-20668
An astrometric facility for planetary detection on the space station
[NASA-TM-89439] p 129 N87-20841
Orbital transfer vehicle concept definition and system analysis study. Volume 1A: Executive summary, Phase 2
[NASA-CR-178886] p 161 N87-21016
A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731
A systems analysis of emergency escape and recovery systems for the US space station
[AD-A178233] p 3 N87-22880
System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5). Volume 1A, part 1: Executive summary, phase 1
[NASA-CR-179139] p 97 N87-25082
System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2
[NASA-CR-179140] p 3 N87-25083
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 2: Cost estimates and work breakdown structure/dictionary, phase 1 and 2
[NASA-CR-179144] p 3 N87-25084
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 2: Supporting research and technology report, phase 1 and 2
[NASA-CR-179143] p 3 N87-25085
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results
[NASA-CR-179142] p 4 N87-25087
Fiber optic data systems p 117 N87-29152
Advanced local area network concepts p 117 N87-29153
Phase 3 study of selected tether applications in space. Volume 1: Executive summary
[NASA-CR-179165] p 131 N87-29585
SYSTEMS ENGINEERING
Water recycling for Space Station p 45 A87-32489
Development of a small-sized space manipulator p 101 A87-51879
An advanced wind scatterometer for the Columbus Polar Platform payload p 156 A87-53117
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 88 N87-20330
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179100] p 181 N87-23677
Assessment of space station power system
[ATES-AN-88/455] p 79 N87-24530
Design and demonstrate the performance of cryogenic components representative of space vehicles: Start basket liquid acquisition device performance analysis
[NASA-CR-179130] p 97 N87-26891
SYSTEMS INTEGRATION
Space Station integration and verification concepts p 84 A87-31481
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 58 A87-33673
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733
Integrated waste and water management system
[SAE PAPER 860999] p 51 A87-38773
ESA's future integrated space data system
[AIAA PAPER 87-2180] p 153 A87-48576
Data capture and processing -- for Space Station
[AIAA PAPER 87-2205] p 113 A87-48842

Integrated scheduling and resource management -- for Space Station Information System
[AIAA PAPER 87-2213] p 119 A87-48587
Space Station Information System integrated communications concept
[AIAA PAPER 87-2228] p 114 A87-48606
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2229] p 114 A87-48607
Advanced EVA system design requirements study: EVAS/space station system interface requirements
[NASA-CR-171981] p 120 N87-20351
Qualification of the faint object camera
p 127 N87-20359
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 9 N87-22716
KSC Space Station Operations Language (SSOL)
p 139 N87-29188
SYSTEMS SIMULATION
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2
[LP-RP-AI-204-VOL-2] p 69 N87-24480
SYSTEMS STABILITY
Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33729
Stability of time varying linear systems
p 7 A87-37135
Joint Optics Structures Experiment (JOSE)
p 34 N87-24497

T

TARGET ACQUISITION
Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-519/86] p 139 N87-20588
TAXONOMY
Distributed computer taxonomy based on O/S structure p 118 N87-29127
TDR SATELLITES
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel
p 113 A87-45495
A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521
Antenna systems and RF coverage for the Space Station p 2 A87-45523
Japanese data relay satellite system
[AIAA PAPER 87-2169] p 154 A87-48585
TECHNOLOGICAL FORECASTING
A simulation capability for future space flight
[SAE PAPER 861784] p 69 A87-32533
The European space programme p 150 A87-37592
Space Station autonomy - What are the challenges? How can they be met? p 101 A87-53050
Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-88993] p 121 N87-23874
TECHNOLOGY ASSESSMENT
K.E. Tsiolkovskii and problems in the development of science and technology -- Russian book
p 151 A87-40342
Advanced technology for the Space Station
p 120 A87-40553
Thoughts on Europe's future in space
p 151 A87-41219
Priorities and policy analysis - A response to Alex Roland p 160 A87-41222
The Space Station overview p 168 A87-41571
Trends in space transportation p 169 A87-41572
Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48597
Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-48586
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340
Cryogenic Fluid Management Flight Experiment (CFMFE) p 95 N87-21150
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 2: Supporting research and technology report, phase 1 and 2
[NASA-CR-179142] p 3 N87-26880
System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results
[NASA-CR-179141] p 4 N87-26888
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-25836
Alternative power generation concepts for space
p 81 N87-26861
High power solar array technologies -- Columbus space station p 82 N87-26876
GaAs concentrator solar arrays p 82 N87-26877
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration
p 83 N87-26885
TECHNOLOGY TRANSFER
The Oak Ridge National Laboratory's Robotics and Intelligent Systems Program
[DE87-004827] p 101 N87-20774
TECHNOLOGY UTILIZATION
NASA's space program - Space Station: A status report and a view of its value for space science
p 1 A87-32277
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 116 A87-33003
A survey of tether applications to planetary exploration
[AAS PAPER 86-208] p 123 A87-38558
Technology and applications - Convergence to a tether capability
[AAS PAPER 86-244] p 124 A87-38574
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712
The Space Station - Uses and users
p 151 A87-40513
European utilisation aspects studies -- space stations
p 156 N87-20824
Ideas for educational physics experiments in space
p 130 N87-25033
Fiber composites in satellites
[MBB-UD-492/86] p 107 N87-25430
TEFLON (TRADEMARK)
Degradation studies of SMRM teflon
p 109 A87-38841
TELECOMMUNICATION
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31482
GLOBECOM '86 - Global Telecommunications Conference, Houston, TX, Dec. 1-4, 1986, Conference Record. Volumes 1, 2, & 3 p 169 A87-45476
The effect of multipath on digital communications systems: With application to space station
[AD-A178570] p 86 N87-22976
TELEMETRY
SPOT solar array in-orbit deployment results evaluation p 83 N87-26888
TELEOPERATORS
Study of actuator for large space manipulator arm
p 12 A87-32545
System architecture for the telerobotic work system
[AAS PAPER 86-044] p 99 A87-32746
Planning for unanticipated satellite servicing teleoperations p 116 A87-33048
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004916] p 101 N87-22231
Traction-drive telerobot for space manipulation
[DE87-005389] p 102 N87-22233
Telerobotic technology for nuclear and space applications
[NASA-CR-180923] p 102 N87-22242
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179188] p 161 N87-23877
Self-calibration strategies for robot manipulators
p 102 N87-26556
Telerobotic work system: Concept development and evolution p 104 N87-26583
Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-26587
TEMPERATURE CONTROL
Thermal verification method for large sized spacecraft
p 144 A87-32368
Development of fluid loop system for spacecraft
p 144 A87-32370
High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-32377
Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 861832] p 41 A87-32582
Prototype thermal bus for manned Space Station compartments
[SAE PAPER 861835] p 41 A87-32585
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860920] p 42 A87-38725
System aspects of Columbus thermal control
[SAE PAPER 860930] p 150 A87-38727
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860936] p 150 A87-38728
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734
Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860979] p 42 A87-38760
Evaluation of Space Station thermal control techniques
[SAE PAPER 860999] p 42 A87-38773
Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 89 A87-38779
Space station active thermal control system modeling
[AIAA PAPER 87-1466] p 43 A87-43003
The benefit of phase change thermal storage for spacecraft thermal management
[AIAA PAPER 87-1482] p 43 A87-43014
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125
Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1628] p 44 A87-43126
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181008] p 45 N87-26072
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-25836
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702
TEMPERATURE DISTRIBUTION
Determination of the cross-sectional temperature distribution and boiling limitation of a heat pipe
p 40 A87-32175
A thermally-pumped heat transport system
p 40 A87-32369
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 69 A87-52947
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021
TEMPERATURE GRADIENTS
On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0937] p 16 A87-33709
Control of flexible structures by applied thermal gradients p 21 A87-39543
TERRESTRIAL PLANETS
Experimentation in planetary geology
p 124 A87-40319
TEST FACILITIES
Martin Marietta atomic oxygen beam facility
p 139 A87-38822
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1856] p 61 A87-45256
Large space structures testing
[NASA-TM-100558] p 35 N87-24520
Absolute indoor calibration of large area solar cells
p 159 N87-26015
TETHERED SATELLITES
Hollow cathode-based plasma contactor experiments for electrodynamic tether
[AIAA PAPER 87-0572] p 121 A87-32182
Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33657
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 123 A87-38557
Tethered satellite program control strategy
[AAS PAPER 86-221] p 123 A87-38570
Technology and applications - Convergence to a tether capability
[AAS PAPER 86-244] p 124 A87-38574
The Tethered Satellite System as a new remote sensing platform p 124 A87-39183
Deployment dynamics of space structures
p 58 A87-40574
Orbital modifications using forced tether-length variations p 124 A87-40899
A three-mass tethered system for micro-g/variable-g applications p 125 A87-40900
Theory of plasma contactors for electrodynamic tethered satellite systems p 65 A87-41659

The mission function control for deployment and retrieval of subsatellite
[AIAA PAPER 87-2326] p 126 A87-50447
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
Thermal and dynamical effects on electrodynamic space tethers
[AD-A180276] p 130 N87-25351
Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-179149] p 130 N87-26083
Electrodynamic tether p 131 N87-26449
TETHERING
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 123 A87-38567
A survey of tether applications to planetary exploration
[AAS PAPER 86-206] p 123 A87-38568
Coaxial tube array space transmission line characterization
[NASA-TM-88964] p 66 N87-22003
Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22509
Optimal shuttle altitude changes using tethers
[AD-A178255] p 129 N87-22758
Electrodynamic tether p 131 N87-26449
Phase 3 study of selected tether applications in space. Volume 1: Executive summary
[NASA-CR-179165] p 131 N87-26685
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-26691
TETHERLINES
Hollow cathode-based plasma contactor experiments for electrodynamic tether
[AIAA PAPER 87-0572] p 121 A87-32192
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533
Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33087
On the dynamical stability of the space 'tramway'
p 140 A87-34047
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-210] p 89 A87-38569
Tether power supplies exploiting the characteristics of space
[AAS PAPER 86-227] p 123 A87-38571
Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572
Tether system and controlled gravity
[AAS PAPER 86-240] p 124 A87-38573
Technology and applications - Convergence to a tether capability
[AAS PAPER 86-244] p 124 A87-38574
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-42510
The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42595
A proposal for space tether damage indication, location, and evaluation - The Repair Monkey Module
p 125 A87-43354
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180822] p 129 N87-22508
Optimal shuttle altitude changes using tethers
[AD-A178255] p 129 N87-22758
Thermal and dynamical effects on electrodynamic space tethers
[AD-A180276] p 130 N87-25351
Phase 3 study of selected tether applications in space. Volume 1: Executive summary
[NASA-CR-179165] p 131 N87-26685
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-26691
TETRAHEDRONS
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21887
THERAPY
Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation
[SAE PAPER 860927] p 103 A87-38717
THERMAL ANALYSIS
Thermal verification method for large sized spacecraft
p 144 A87-32369
Thermal design of the ACCESS erectable space truss
p 42 A87-34489
Quality monitoring in two-phase heat transport systems for large spacecraft
[SAE PAPER 860983] p 42 A87-38743
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-48882
THERMAL CONTROL COATINGS
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103
Space stable thermal control coatings
[AD-A182756] p 110 N87-28584
THERMAL CYCLING TESTS
Joint technology for graphite epoxy space structures
p 20 A87-38800
Assessment of space environment induced microdamage in toughened composite materials
p 20 A87-38809
THERMAL DEGRADATION
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32348
Thermal deformation and electrical degradation of antenna reflector with truss backstructure
p 12 A87-32405
THERMAL ENERGY
A transient analysis of phase change energy storage system for solar dynamic power
[AIAA PAPER 87-1489] p 77 A87-43004
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-88886] p 76 N87-22174
THERMAL EXPANSION
Composite space antenna structures - Properties and environmental effects p 20 A87-38810
Measuring thermal expansion in large composite structures -- for spaceborne telescopes
p 20 A87-38812
Tayloured laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794
THERMAL PLASMAS
Potential modulations on SCATHA (Spacecraft Charging At High Altitudes) spacecraft
[AD-A178815] p 140 N87-21024
THERMAL PROTECTION
Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 861499] p 41 A87-32092
Prototype thermal bus for manned Space Station components
[SAE PAPER 861521] p 41 A87-32093
Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1585] p 160 A87-43051
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets
p 45 N87-28192
THERMAL SIMULATION
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181050] p 45 N87-26172
THERMAL STABILITY
Tayloured laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794
Space stable thermal control coatings
[AD-A182756] p 110 N87-28584
THERMAL STRESSES
Radiation heat transfer calculations for space structures
[AIAA PAPER 87-1522] p 44 A87-44883
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327
Dynamic and thermal effects in very large space structures p 25 N87-26047
THERMAL VACUUM TESTS
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860959] p 150 A87-38739
THERMODYNAMIC CYCLES
A transient analysis of phase change energy storage system for solar dynamic power
[AIAA PAPER 87-1489] p 77 A87-43004
THERMOELECTRIC GENERATORS
Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-88893] p 121 N87-23874
THERMOELECTRICITY
On the control of structures by applied thermal gradients p 33 N87-22747
THERMOSPHERE
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations
[NASA-CP-2460] p 84 N87-26588
THRUST CHAMBERS
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 68 N87-22133
THRUST CONTROL
Preliminary evaluation of a reaction control system for the space station p 67 N87-22738
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
THRUST DISTRIBUTION
Dynamic behavior of astronauts and satellites outside an orbiting space station under the influence of thrust
p 52 A87-41888
THRUST PROGRAMMING
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41915
THRUST VECTOR CONTROL
Conceptual design and integration of a Space Station resistojet propulsion assembly
[AIAA PAPER 87-1860] p 91 A87-45258
Conceptual design and integration of a space station resistojet propulsion assembly
[NASA-TM-88947] p 93 N87-20279
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25355
TIME MEASUREMENT
Proof that timing requirements of the FDDI token ring protocol are satisfied -- fiber distributed data interface
p 112 A87-42821
TIME SHARING
On the performance analysis of a real-time distributed computer system p 111 A87-21519
TIMOSHENKO BEAMS
Dynamic response of a viscoelastic Timoshenko beam
[AIAA PAPER 87-0890] p 16 A87-33798
TIN OXIDES
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets
p 45 N87-28192
TITAN
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002
TORQUE
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50321
TORQUE MOTORS
Study of actuator for large space manipulator arm
p 12 A87-32545
TORSION
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 108 A87-25300
TORSIONAL VIBRATION
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-48121
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50093
TOWED BODIES
Optimal shuttle altitude changes using tethers
[AD-A178255] p 129 N87-22758
TOXIC HAZARDS
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 104 A87-40888
TRACE CONTAMINANTS
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration
[SAE PAPER 860916] p 47 A87-38758
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53879
TRACKING (POSITION)
Solar array flight dynamic experiment
[AAS PAPER 86-050] p 75 A87-32747
TRACKING NETWORKS
Japanese data relay satellite system
[AIAA PAPER 87-2180] p 154 A87-48868
TRACTION
Traction-drive telerobot for space manipulation
[DE87-005820] p 102 N87-23333
Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-26987
TRADEOFFS
Space Station EVA systems trade-off model
[SAE PAPER 860920] p 134 A87-38767
TRAINING ANALYSIS
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180942] p 53 N87-27405
TRAJECTORIES
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182850] p 61 N87-28168

225

TRAJECTORY ANALYSIS
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540
TRAJECTORY OPTIMIZATION
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31681
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41615
Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2567] p 93 A87-48817
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2509] p 136 A87-48816
TRANSFER FUNCTIONS
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739
TRANSFER ORBITS
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31681
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41615
Optical correlator use at Johnson Space Center p 59 A87-42666
NERVA derived nuclear orbit transfer system
[AIAA PAPER 87-2135] p 92 A87-45429
Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2567] p 93 A87-48817
TRANSIENT LOADS
Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20589
TRANSIENT RESPONSE
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 58 A87-33573
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33759
An experimental study of transient waves in a plane grid structure
[AIAA PAPER 87-0943] p 18 A87-33741
Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41611
A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 26 N87-25337
Response of joint dominated space structures
[NASA-CR-180004] p 39 N87-20071
Response of joint dominated space structures
[NASA-CR-181202] p 37 N87-26097
TRANSLATIONAL MOTION
Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-43587
TRANSMISSION LINES
Coaxial tube array space transmission line characterization
[NASA-TM-88964] p 98 N87-22003
TRANSMITTER RECEIVERS
The effect of multipath on digital communications systems: With application to space station
[AD-A178579] p 98 N87-22879
Fiber optics wavelength division multiplexing/components p 117 N87-29151
Fiber optics common transceiver module p 117 N87-29160
TRANSPARENCE
Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182023] p 110 N87-27689
TRANSPORTER
The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29000
TRAVELING WAVES
Localization in disordered periodic structures
[AIAA PAPER 87-0819] p 19 A87-33757
Some problems in the control of large space structures
[AD-A179000] p 70 N87-25309
Active vibration damping of flexible structures using the traveling wave approach p 71 N87-25300
TREATMENT
When the doctor is 200 miles away p 47 A87-26680
TRIBOLOGY
Development of harmonic drive actuator for space manipulator p 149 A87-25079
TRUSSES
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341
Development of graphite epoxy space structure p 105 A87-32342
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32546
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33584
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0866] p 14 A87-33632
Design considerations for a one-kilometer antenna dish
[AIAA PAPER 87-0871] p 15 A87-33635
Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33667
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33670
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739
Wave propagation in periodic truss structures
[AIAA PAPER 87-0944] p 18 A87-33742
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-34487
Thermal design of the ACCESS erectable space truss p 42 A87-34489
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts p 19 A87-35327
A hybrid nonlinear programming method for design optimization p 7 A87-35716
Composite tubes for the Space Station truss structure p 20 A87-38801
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures p 21 A87-40575
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-49121
Development of full scale deployable CFRP truss for space structure p 25 A87-51700
Modeling of joints for the dynamic analysis of truss structures
[NASA-TP-2661] p 29 N87-20587
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21057
Dynamics of trusses having nonlinear joints p 32 N87-22724
Equivalent beam modeling using numerical reduction techniques p 32 N87-22725
Dual keel space station control/structures interaction study p 67 N87-22737
Experimental characterization of deployable trusses and joints p 33 N87-22748
Box truss antenna technology status p 87 N87-24003
Hoop/column and tetrahedral truss electromagnetic tests p 87 N87-24004
Application of physical parameter identification to finite-element models p 34 N87-24025
Design, development and fabrication of a deployable/retractable truss beam model for large space structures application
[NASA-CR-178287] p 35 N87-25348
Deployable geodetic truss structure
[NASA-CASE-LAR-13113-1] p 36 N87-25482
Collet lock joint for space station truss
[NASA-CASE-MSC-21207-1] p 36 N87-25576
Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89089] p 37 N87-26086
Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180300] p 37 N87-26093
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures — spacecraft masts
[NASA-CR-180917] p 38 N87-27300
Remote handling facility and equipment used for space truss assembly
[DE87-009121] p 100 N87-27409
Preloaded space structural coupling joints
[NASA-CASE-LAR-13489-1] p 39 N87-27715
Folding, articulated, square truss p 40 N87-28800
The design and development of a two-dimensional adaptive truss structure p 40 N87-28860
The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29000
TUBES
Composite tubes for the Space Station truss structure p 20 A87-38801
Microcrack resistant structural composite tubes for space applications p 108 A87-41022
TURBINES
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 168 A87-25300
TURBOGENERATORS
Organic Rankine cycle power conversion systems for space applications p 159 N87-26808
TWO DIMENSIONAL BODIES
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341
The design and development of a two-dimensional adaptive truss structure p 40 N87-28860
TWO PHASE FLOW
Quality monitoring in two-phase heat transport systems for large spacecraft
[SAE PAPER 860963] p 42 A87-33743
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125
Microgravity fluid management in two-phase thermal systems p 95 N87-21152
Two-phase reduced gravity experiments for a space reactor design p 5 N87-21154

U

U.S.S.R.
Status of orbital astronomy projects p 135 N87-21873
U.S.S.R. SPACE PROGRAM
Contribution of the German Democratic Republic (East Germany) to the 'Interkosmos' program of study of materials in space aboard the orbiting station Salyut 6 p 147 A87-28914
Manned space flight — comparisons between U.S. and U.S.S.R. programs p 167 A87-29819
International cooperation in space p 149 A87-34594
Advances by the Soviet Union in space cooperation and commercial marketing made 1986 a landmark year p 149 A87-34595
The Gagarin scientific lectures in astronautics and aviation, 1985 — Russian book p 152 A87-42823
Mir - A second Sputnik? p 153 A87-45572
The Soviet space shuttle programme p 153 A87-47308
The GDR and the Soviet space program - The optical instrument sector of the GDR contributions p 135 A87-53000
Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20752
UK SPACE PROGRAM
British activities in space p 143 A87-32299
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015
Columbus/Space Station United Kingdom Utilisation Study 1985/6 Report - Executive Summary p 151 A87-41429
A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K. p 125 A87-41430
Space Station opportunity for UK in earth sensing p 152 A87-41679
Ion thrusters advance p 89 A87-54169
ULLAGE
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
ULTRAHIGH FREQUENCIES
On-board K- and S-band multi-beam antennas p 84 A87-46601
UNDERWATER RESEARCH LABORATORIES
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180942] p 53 N87-21485
UNIONS (CONNECTORS)
Preloaded space structural coupling joints
[NASA-CASE-LAR-13489-1] p 39 N87-27715
UNMANNED SPACECRAFT
Mir in action p 156 A87-37971
We shouldn't build the Space Station now p 160 A87-42075
UPPER STAGE ROCKET ENGINES
Space launcher upper stages - Design for mission versatility and/or orbital operation p 132 A87-33474
UREAS
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860985] p 50 A87-33794

USER REQUIREMENTS
Commercial US transfer vehicle overview
[SAE PAPER 861764] p 1 A87-32525
User interface design guidelines for expert troubleshooting systems -- for Space Station
p 6 A87-33050
Japanese customer needs for Space Station
[AIAA PAPER 87-2180] p 153 A87-48580
Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2185] p 153 A87-48581
Scientific customer needs - NASA user
[AIAA PAPER 87-2188] p 119 A87-48582
Standards for the user interface - Developing a user consensus -- for Space Station Information System
[AIAA PAPER 87-2229] p 169 A87-48584
Advanced EVA system design requirements study: EVAS/space station system interface requirements
[NASA-CR-171991] p 120 N87-20351
European utilization aspects studies -- space stations
p 138 N87-25624
UTILIZATION
Columbus/Space Station United Kingdom Utilisation Study 1985/6 Report - Executive Summary
p 151 A87-41425

V

VACUUM TESTS
Study of actuator for large space manipulator arm
p 12 A87-32545
VAPOR PHASES
Phase change water recovery for Space Station - Parametric testing and analysis
[SAE PAPER 860880] p 81 A87-38765
VAPORIZING
Production of pulsed atomic oxygen beams via laser vaporization methods p 106 A87-29825
VAPORS
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
VARIABILITY
A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications
[NASA-CR-177447] p 130 N87-25787
VARIABLE GEOMETRY STRUCTURES
Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33587
Problems of mechanical system configuration control
p 140 A87-35677
VECTOR CURRENTS
Polarizable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 161 N87-25562
VENTING
Space-based OTV boiloff disposition
[AIAA PAPER 87-1767] p 91 A87-45191
VERSATILITY
20 kHz Space Station power system
p 76 A87-40375
VHSIC (CIRCUITS)
A VHSIC general purpose processor
p 116 N87-29145
VIBRATION
The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Blast and Ground Shock, Shock Testing and Analysis
[AD-A175234] p 29 N87-20574
Guidelines for noise and vibration levels for the space station
[NASA-CR-178310] p 129 N87-24182
VIBRATION DAMPING
A consideration to vibration control for a large space structures p 54 A87-32441
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Vibration control for a linked system of flexible structures p 55 A87-32444
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel
p 55 A87-32448
Control of a flexible space manipulator
p 55 A87-32449
Low-authority control through passive damping
[AAS PAPER 86-004] p 56 A87-32730
Vibration suppression using a constrained rate-feedback Threshold control strategy -- for large space structures
[AIAA PAPER 87-0741] p 6 A87-33585
An identification method for flexible structures
[AIAA PAPER 87-0745] p 16 A87-33589
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure
[AIAA PAPER 87-0886] p 16 A87-33689
On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0887] p 16 A87-33708
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0951] p 19 A87-34701
Control of flexible structures by applied thermal gradients p 21 A87-36543
The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0951] p 59 A87-38644
Gradient-based combined structural and control optimization p 21 A87-42898
Modelling, stabilization and control of serially connected beams p 21 A87-41052
Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47912
Material damping in aluminum and metal matrix composites p 109 A87-48787
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2349] p 60 A87-50413
Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2350] p 60 A87-50414
The control of linear dampers for large space structures
[AIAA PAPER 87-2351] p 60 A87-50415
Active damping control design for the COFS Mast Flight System -- Control of Flexible Structures program for NASA
[AIAA PAPER 87-2321] p 23 A87-50442
Active vibration control synthesis for the COFS-I - A classical approach -- Control of Flexible Structures experiment for NASA
[AIAA PAPER 87-2322] p 23 A87-50443
Suboptimal feedback vibration control of a beam with a proof-mass actuator -- large space structures
[AIAA PAPER 87-2323] p 23 A87-50444
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502
Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2589] p 62 A87-50681
Effect of modal damping in modal synthesis of spacecraft structures p 26 N87-20582
Modal-survey testing for system identification and dynamic qualification of spacecraft structures
p 27 N87-20585
Benefits of passive damping as applied to active control of large space structures p 63 N87-20871
Modeling and control of flexible structures
p 29 N87-20894
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180063] p 29 N87-20909
Modeling and control of flexible structures
[AD-A177166] p 29 N87-21399
Optimum mix of passive and active control of space structures p 65 N87-22714
Status report and preliminary results of the spacecraft control laboratory experiment p 65 N87-22717
Dynamics of trusses having nonlinear joints
p 32 N87-22724
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
Vibration suppression by stiffness control
p 65 N87-22730
Impact of space station appendage vibrations on the pointing performance of gimbaled payloads
p 32 N87-22733
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734
Slewing control experiment for a flexible panel
p 75 N87-22740
A new approach for vibration control in large space structures p 33 N87-22743
Crew activity and motion effects on the space station
p 165 N87-22744
On the control of structures by applied thermal gradients p 33 N87-22747
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181085] p 34 N87-22980
NASA/DOD Control/Structures Interaction Technology, 1986
[NASA-CP-2447-PT-2] p 34 N87-24485
Joint Optics Structures Experiment (JOSE)
p 34 N87-24487
Application of physical parameter identification to finite-element models p 34 N87-24505
Structural control by the use of piezoelectric active members p 69 N87-24509
Research in slewing and tracking control
p 70 N87-24512
Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180391] p 70 N87-24513
Investigation for damping design and related nonlinear vibrations of spacecraft structures
[illegible] p 35 N87-24516
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179725] p 35 N87-24517
Distributed control using linear momentum exchange devices
[NASA-TM-100000] p 70 N87-24521
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-88884] p 70 N87-24725
Some problems in the control of large space structures
[AD-[illegible]] p 70 N87-25350
[illegible] vibration damping of flexible structures using the [illegible] wave approach p 71 N87-25352
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181150] p 39 N87-25885
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A178711] p 72 N87-25895
Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-26367
Active vibration control in microgravity environment
p 73 N87-26705
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2351-VOL-1] p 73 N87-27769
An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-28907
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29713
VIBRATION ISOLATORS
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180063] p 29 N87-20909
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
Vibration isolation for line of sight performance improvement p 67 N87-22742
Crew activity and motion effects on the space station
p 165 N87-22744
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
Theory and application of linear servo dampers for large scale space structures p 72 N87-25870
Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A180051] p 110 N87-27050
A microgravity isolation mount p 161 N87-28881
VIBRATION MODE
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32129
Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0825] p 14 A87-33613
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0903] p 17 A87-33712
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739
An experimental study of transient waves in a plane grid structure
[AIAA PAPER 87-0943] p 18 A87-33741
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41913
Modal-survey testing of the Olympus spacecraft
p 152 A87-42999

Dynamics of gyroelastic spacecraft p 59 A87-47811
Effect of modal damping in modal synthesis of spacecraft structures p 28 N87-20392
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22709
Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22729

VIBRATION TESTS
On sine dwell or broadband methods for modal testing [AIAA PAPER 87-0801] p 18 A87-33752
A modern approach for modal testing using multiple input sine excitation [AIAA PAPER 87-0804] p 19 A87-33754
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41913
Modal-survey testing of the Olympus spacecraft p 152 A87-42269
Low frequency vibration testing on satellites p 27 N87-20384
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20385
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373

VIBRATIONAL SPECTRA
Modeling and control of flexible structures [AD-A177100] p 29 N87-21389

VIDEO DATA
Video image processing p 118 N87-29150

VIDEO EQUIPMENT
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370
Video image processing p 118 N87-29150

VIDEO SIGNALS
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370

VISCOELASTIC DAMPING
Dynamic response of a viscoelastic Timoshenko beam [AIAA PAPER 87-0890] p 16 A87-33758

VISCOELASTICITY
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures [AD-A180332] p 11 N87-26980

VISCOUS DAMPING
Variable structure controller design for spacecraft nutation damping p 59 A87-26956
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures p 21 A87-40875
Response bounds for linear underdamped systems [ASME PAPER 87-APM-34] p 59 A87-42533
Dynamic qualification of spacecraft by means of modal synthesis p 28 N87-20393
Benefits of passive damping as applied to active control of large space structures p 60 N87-20371

VOICE CONTROL
Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 99 A87-21482

W

WAKES
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved p 142 N87-26946
Documentation for the SHADO particle wake routine [AD-A181631] p 131 N87-26887

WALLS
Space station integrated wall design and penetration damage control [NASA-CR-179165] p 39 N87-25091
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics [NASA-CR-179166] p 39 N87-25092
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system [NASA-CR-179167] p 4 N87-25093
Vibrations and structureborne noise in space station [NASA-CR-181331] p 39 N87-26990

WARFARE
Present and future military uses of outer space: International law, politics, and the practice of states [AD-A179732] p 170 N87-21753

WARNING SYSTEMS
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-45598

WASTE DISPOSAL
An improved waste collection system for space flight [SAE PAPER 881014] p 118 A87-38764

WASTE TREATMENT
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR) [SAE PAPER 860985] p 50 A87-38764
Integrated waste and water management system [SAE PAPER 860998] p 51 A87-38773
CELSS waste management systems evaluation [SAE PAPER 860997] p 51 A87-38774
Electrochemical processing of solid waste [NASA-CR-181128] p 137 N87-25443

WASTE UTILIZATION
Hydrogen/oxygen economy for the space station p 58 N87-29130

WASTE WATER
Water recycling for Space Station p 48 A87-32458
Pre- and post-treatment techniques for spacecraft water recovery [SAE PAPER 860982] p 50 A87-38761
Results on reuse of reclaimed shower water [SAE PAPER 860983] p 50 A87-38762
A membrane-based subsystem for very high recoveries of spacecraft waste waters [SAE PAPER 860984] p 50 A87-38763
Phase change water recovery for Space Station - Parametric testing and analysis [SAE PAPER 860986] p 51 A87-38765
Supercritical water oxidation - Concept analysis for evolutionary Space Station application [SAE PAPER 860993] p 51 A87-38770

WATER
Gas and water recycling system for IOC vivarium experiments -- Initial Operational Capacity p 48 A87-32457
Hydrogen/oxygen economy for the space station p 58 N87-29130
Water-propellant resupply for man-tended platforms [NASA-TM-100110] p 58 N87-29135

WATER MANAGEMENT
Integrated waste and water management system [SAE PAPER 860998] p 51 A87-38773
The impact of integrated water management on the Space Station propulsion system [AIAA PAPER 87-1854] p 81 A87-45259

WATER QUALITY
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-45598
Quality requirements for reclaimed/recycled water [NASA-TM-89279] p 53 N87-27392

WATER RECLAMATION
Water recycling system using thermopervaporation method p 48 A87-32459
Water recycling for Space Station p 48 A87-32458
Pre- and post-treatment techniques for spacecraft water recovery [SAE PAPER 860982] p 50 A87-38761
Results on reuse of reclaimed shower water [SAE PAPER 860983] p 50 A87-38762
A membrane-based subsystem for very high recoveries of spacecraft waste waters [SAE PAPER 860984] p 50 A87-38763
Phase change water recovery for Space Station - Parametric testing and analysis [SAE PAPER 860986] p 51 A87-38765
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs [SAE PAPER 860987] p 51 A87-38766
The impact of integrated water management on the Space Station propulsion system [AIAA PAPER 87-1854] p 81 A87-45259
Quality requirements for reclaimed/recycled water [NASA-TM-89279] p 53 N87-27392

WATER TREATMENT
Results on reuse of reclaimed shower water [SAE PAPER 860983] p 50 A87-38762
A membrane-based subsystem for very high recoveries of spacecraft waste waters [SAE PAPER 860984] p 50 A87-38763
Phase change water recovery for Space Station - Parametric testing and analysis [SAE PAPER 860986] p 51 A87-38765
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs [SAE PAPER 860987] p 51 A87-38766
Supercritical water oxidation - Concept analysis for evolutionary Space Station application [SAE PAPER 860993] p 51 A87-38770

WAVE ATTENUATION
Localization in disordered periodic structures [AIAA PAPER 87-0819] p 19 A87-33757

WAVE PROPAGATION
An experimental study of transient waves in a plane grid structure [AIAA PAPER 87-0943] p 18 A87-33741
Wave propagation in periodic truss structures [AIAA PAPER 87-0944] p 18 A87-33742
Wave-mode coordinates and scattering matrices for wave propagation [AD-A176858] p 29 N87-21030
Comparison of wave-mode coordinate and pulse summation methods [AD-A177795] p 30 N87-21962
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures) [AD-A177271] p 30 N87-22256
Modeling of controlled flexible structures with impulsive loads p 33 N87-22745

WAVE SCATTERING
Wave-mode coordinates and scattering matrices for wave propagation [AD-A176858] p 29 N87-21030

WAVEGUIDE ANTENNAS
Carbon fibre slotted waveguide arrays p 85 A87-41302

WEIGHT REDUCTION
Structural optimization with frequency constraints [AIAA PAPER 87-0787] p 13 A87-33688
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure [AIAA PAPER 87-0883] p 16 A87-33689
A basis change strategy for the reduced gradient method and the optimum design of large structures p 23 A87-46341
Use of lightweight composites for GAS payload structures p 25 N87-20307

WEIGHTLESS FLUIDS
Analytical and experimental modeling of zero/low gravity fluid behavior [AIAA PAPER 87-1838] p 81 A87-45266
Mixing-induced ullage condensation and fluid destratification [AIAA PAPER 87-2018] p 82 A87-45307
Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation [AIAA PAPER 87-2021] p 82 A87-45309

WEIGHTLESSNESS
A question of gravity p 1 A87-52116
Identification of the zero-g shape of a space beam [AIAA PAPER 87-0872] p 15 A87-33690
Microgravity Fluid Management Symposium [NASA-CP-2465] p 84 N87-21141

WEST GERMANY
Highlights of the German Space Programme p 143 A87-52262

WIND MEASUREMENT
An advanced wind scatterometer for the Columbus Polar Platform payload p 156 A87-52117
Flight array processor p 116 N87-29148

WIRE
Analytical solutions for static elastic deformations of wire ropes [AIAA PAPER 87-0780] p 8 A87-33681
Initial investigations into the damping characteristics of wire rope vibration isolators [NASA-CR-180080] p 28 N87-20900

WORKING FLUIDS
Development of fluid loop system for spacecraft p 144 A87-32270
Development of a prototype two-phase thermal bus system for Space Station [AIAA PAPER 87-1628] p 44 A87-43129

WORKLOADS (PSYCHOPHYSIOLOGY)
Energy expenditure during simulated EVA workloads [SAE PAPER 860921] p 160 A87-38713
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20736
Workshop on Workload and Training, and Examination of their Interactions: Executive summary [NASA-TM-88405] p 171 N87-25780

WORKSTATIONS
The development of an EVA Universal Work Station [SAE PAPER 860952] p 164 A87-38739
BOT: A rapid prototype using TAE windows p 114 N87-29161
A workstation environment for software engineering p 116 N87-29129
Electronic control/display interface technology p 88 N87-29161
User interface and payload command and control p 73 N87-29162

X

X RAY ASTRONOMY
Grazing incidence telescopes for X-ray astronomy p 123 A87-37766
'XEXE' - X-ray observatory in space p 155 A87-53656
Status of orbital astronomy projects p 126 N87-21873

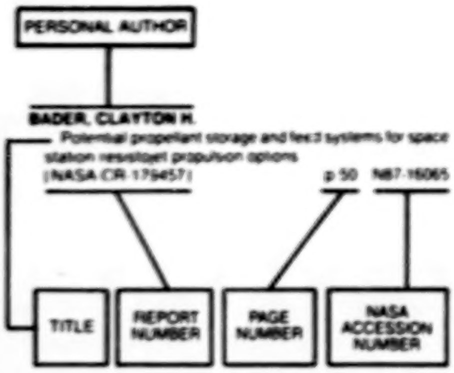
X RAY SOURCES
Mir in action p 150 A87-37971
X RAY TELESCOPES
Coded mask telescopes for X-ray astronomy
p 123 A87-37785

Y

YOKES
Preloadable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 161 N87-25582

PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g. NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

ABE, TOSHIO
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32288

ABEL, JOSEPH E.
Satellite servicing logistics
[SAE PAPER 861723] p 132 A87-32612

ABELES, FRED
The development of an EVA Universal Work Station
[SAE PAPER 860952] p 164 A87-38739

ABELES, FRED J.
Physiological aspects of EVA
[SAE PAPER 860901] p 164 A87-38768

ABHYANKAR, NANDAKISHOR SADASHIV
Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 28 N87-20348

ABROUS, A.
Radiation heat transfer calculations for space structures
[AIAA PAPER 87-1522] p 44 A87-44830

ACRES, WILLIAM R.
Preloadable vector sensitive latch
[NASA-CASE-MSC-20810-1] p 161 N87-25582
The preloadable vector sensitive latch for orbital docking/berthing p 162 N87-29876

ADACHI, TADASHI
A consideration to vibration control for a large space structures p 54 A87-32441

ADAMIAN, A.
Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32657

ADAMIAN, ARMEN
Integrated control/structure design and robustness p 65 N87-22080

ADAMS, LOUIS R.
Design, development and fabrication of a deployable/retractable truss beam model for large space structures application
[NASA-CR-178287] p 35 N87-25349

ADELMAN, H. M.
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33811

ADELMAN, HENRY G.
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49815

AGGSON, T.
Potential modulation on the SCATHA spacecraft p 138 A87-34480
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A178815] p 140 N87-21024

AGRAWAL, B.
Analysis of Intelsat V flight data
[AIAA PAPER 87-0784] p 16 A87-33679

AGRAWAL, B. L.
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-29006

AGRAWAL, B. N.
Comparison of different attitude control schemes for large communications satellites
[AIAA PAPER 87-2361] p 61 A87-50475

AJIMA, HIROSHI
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547

AKIBA, RYOJIRO
Japanese space program p 143 A87-32285

ALBRIDGE, R. G.
The Vanderbilt University neutral O-beam facility p 105 A87-32059
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-28191

ALLAN, T. D.
Ocean-ice panel report p 156 N87-20635

ALLEN, D. H.
Dynamic response of a viscoelastic Timoshenko beam
[AIAA PAPER 87-0890] p 16 A87-33708

ALLEN, JOHN L.
Status of the Mast experiment p 30 N87-22703

ALLURES, S.
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1858] p 91 A87-45255

ALLURES, S. L.
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132

ALTMANN, THOMAS
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532

ALTON, T. JAMES
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1488] p 90 A87-43027

AMADIEU, PATRICE
Qualification of the faint object camera p 127 N87-20359

AMBRUS, JUDITH H.
Space station: A program overview p 171 N87-24496

AMIROUCHE, M. L.
Flexibility effects - Estimation of the stiffness matrix in the dynamics of a large structure p 23 A87-48714

AMOS, ANTHONY K.
Air Force basic research in dynamics and control of large space structures p 63 N87-20577

AN, SONG H.
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel p 113 A87-45486

ANDERSEN, G. C.
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50562

ANDERSEN, GREGORY C.
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021

ANDERSON, JOHN L.
Technology and applications - Convergence to a tether capability
[AAS PAPER 86-244] p 124 A87-38574

ANDO, Y.
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443

ANTIN, JONATHAN F.
An evaluation of menu systems for Space Station interfaces p 111 A87-33040

ANTONIAK, ZENEN I.
Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154

APPLEBY, A. JOHN
Regenerative fuel cells for space applications p 84 N87-29839

ARAI, FUMIHITO
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50033

ARAJ, K.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

ARAKAWA, ATSUSHI
Control of a flexible space manipulator p 99 A87-32448

ARCHULETA, F. A.
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 105 A87-32060
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-28186

ARCHULETA, F. H.
Mass spectrometers and atomic oxygen p 141 N87-28176

ARMSTRONG, E. S.
Robust controller synthesis for a large flexible space antenna p 84 A87-32236
A spline-based parameter and state estimation technique for static models of elastic surfaces
[NASA-CR-180449] p 11 N87-30107

ARNO, ROGER D.
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-38740

ARNOLD, GRAHAM S.
Laboratory studies of atomic oxygen reactions with solids p 4 N87-28196

ARTRUSHIN, L. M.
Problems of mechanical system configuration control p 149 A87-35877

ASHIDA, AKIRA
Water recycling system using thermopervaporation method p 48 A87-32458
Water recycling for Space Station p 46 A87-32459
Autonomous decentralized system concept for Space Station p 148 A87-32541

ATLAS, G.
SPOT/MEGS design and flight results obtained p 103 N87-29008
Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29009

ATWELL, W.
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-40026

AUBRUN, JEAN-NOEL
Maximum likelihood identification using an array processor p 5 A87-32121

AUFFRAY, P.
The high performance solar array GSR3 p 81 N87-28972

AUSTIN, ERIC M.
The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0891] p 56 A87-33644

AVDUYEVSKIY, V. S.
Plans for industrialization of space discussed p 157 N87-21979

AWAZAWA, H.
Japanese data relay satellite system
[AIAA PAPER 87-2189] p 154 A87-49586

AYDELOTT, J. C.
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 93 A87-52247

AYDELOTT, JOHN C.
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[AIAA PAPER 87-1764] p 92 A87-48572
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply
[NASA-TM-89921] p 96 N87-22949

AZUMA, HISAO
Solar concentrator system for experiments in the Space Station p 146 A87-32535

B

BABCOCK, CHARLES D.
Design considerations for a one-kilometer antenna stick
[AIAA PAPER 87-0871] p 15 A87-33635
Identification of the zero-g shape of a space beam
[AIAA PAPER 87-0872] p 15 A87-33636

BABEL, HENRY W.
Microcrack resistant structural composite tubes for space applications p 108 A87-41022

BACHTELL, E. E.
Box truss antenna technology status p 87 N87-24503

BAE, GYOUNG H.
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2569] p 136 A87-48818

BAGDIGIAN, ROBERT
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs
[SAE PAPER 860987] p 51 A87-38766

BAILEY, M. C.
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33611
Hoop/column and tetrahedral truss electromagnetic tests p 87 N87-24504

BAILEY, MARION C.
Controls-structures-electromagnetics interaction program p 89 N87-24502

BAINS, E. M.
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-58221] p 137 N87-25339

BAINUM, PETER M.
A review of modelling techniques for the open and closed-loop dynamics of large space systems p 12 A87-32237
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 p 123 A87-38567
Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26038
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712

BAKER, D. JAMES
A crisis in the NASA space and earth sciences programme p 112 A87-37969

BAKER, MARY
Comparison of the Craig-Bampton and residual flexibility methods of substructure representation p 19 A87-34510

BALAS, GARY J.
Identification of the zero-g shape of a space beam
[AIAA PAPER 87-0872] p 15 A87-33636

BALMAIN, K. G.
Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-26952

BALODIS, VILNIS
Space station power semiconductor package
[NASA-CR-180829] p 81 N87-26825

BANKS, BRUCE
An evaluation of candidate oxidation resistant materials for space applications in LEO
[NASA-TM-100122] p 107 N87-25480
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation p 131 N87-26189
An evaluation of candidate oxidation resistant materials p 110 N87-26203

BANKS, BRUCE A.
Oxidation protection coatings for polymers
[NASA-CASE-LEW-14072-3] p 107 N87-23736

BANKS, H. T.
A spline-based parameter and state estimation technique for static models of elastic surfaces
[NASA-CR-180449] p 11 N87-30107

BANKS, PETER M.
A crisis in the NASA space and earth sciences programme p 112 A87-37969

BANTELL, M. H., JR.
Precision pointing and control of flexible spacecraft p 66 N87-22723

BARAONA, COSMO
High power/large area PV systems p 80 N87-26452

BARAONA, COSMO R.
Space station power system p 80 N87-26447
The space station power system p 81 N87-29960
Status of space station power system p 84 N87-29915

BARBAY, GORDON J.
Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41611

BARBERIS, NEIL J.
Geostationary platforms - An international perspective p 121 A87-32286

BARBIERI, E.
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445

BARCLAY, J. A.
Magnetic refrigeration for space platforms
[SAE PAPER 861724] p 118 A87-32613

BAREISS, LYLE
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-26204

BAREISS, LYLE E.
Martin Marietta atomic oxygen beam facility p 139 A87-38622

BARNES, A. V.
The Vanderbilt University neutral O-beam facility p 105 A87-32059

BARNES, W. L.
Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS p 128 A87-44186

BARRET, MICHAEL F.
Robust control of a large space antenna
[AIAA PAPER 87-2253] p 66 A87-50417

BARRETT, M. F.
Robust control for large space antennas p 87 N87-24489

BARTEVIAN, J.
The high performance solar array GSR3 p 81 N87-29972

BARTHEL, J.
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6 p 147 A87-32814

BARTOLI, C.
Status of the RITA - Experiment on EURECA
[AIAA PAPER 87-0998] p 122 A87-38002

BASAPUR, V. K.
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31681

BASSNER, H.
Status of the RITA - Experiment on EURECA
[AIAA PAPER 87-0998] p 123 A87-38002

BASSO, G. L.
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370

BASTARD, J. L.
The high performance solar array GSR3 p 81 N87-29972

BASTON, D.
Modal-survey testing of the Olympus spacecraft p 152 A87-42288

BATTRICK, B.
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-260] p 128 N87-20621

BAUER, FRANK H.
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-051] p 56 A87-32736

BAUER, H. F.
Dynamic behavior of astronauts and satellites outside an orbiting space station under the influence of thrust p 52 A87-41668

BAUER, J. L.
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets p 45 N87-26182

BAYES, STEPHEN A.
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734

BAZ, A.
Actuators for actively controlled space structures p 59 A87-42816
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181065] p 34 N87-23660
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181156] p 36 N87-25605
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29713
Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-29886

BEATTY, R.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145

BEATTY, RICHARD
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89295] p 79 N87-25836

BECK, JUERGEN W.
Highlights of the German Space Programme p 143 A87-32282

BECKMAN-DAVIES, C. S.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

BECKMANN, K.
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860936] p 42 A87-38725
System aspects of Columbus thermal control
[SAE PAPER 860938] p 150 A87-38727

BEEVER, R.
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-49026

BEGIAN, YVETTE M.
Desirability of arms-in capability in space suits
[SAE PAPER 860951] p 49 A87-38736

BEHRENS, G.
High power solar array technologies p 82 N87-29976

BEKEY, IVAN
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 p 122 A87-38567

BELIAEV, M. IU.
Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34209

BELISLE, J.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

BELL, CHARLES E.
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42817

BELVIN, W. KEITH
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0889] p 15 A87-33833
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41613
Modeling of joints for the dynamic analysis of truss structures
[NASA-TP-2661] p 29 N87-20567

BELVIN, WENDELL K.
Controls-structures-electromagnetics interaction program p 89 N87-24502

BELYAYEV, M. YU.
Optimizing experimental programs in operational planning of research carried out from spacecraft p 160 N87-29553

BENDIKSEN, ODDVAR O.
Localization of vibrations in large space reflectors
[AIAA PAPER 87-0949] p 18 A87-33745

BENENATI, R.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

BENKLAASSENS, J.
Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2319] p 79 N87-24533

BENNETT, F. O., JR.
Modeling of fluid transfer in orbit
[AIAA PAPER 87-1763] p 80 A87-45180

BENNETT, W. H.
Practical issues in computation of optimal, distributed control of flexible structures
[AIAA PAPER 87-2481] p 25 A87-50507
Modeling and control of flexible structures
[AD-A177108] p 29 N87-21388

BENNETT, WILLIAM H.
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179726] p 35 N87-24517

BENNIGHOF, JEFFREY KENT
Modeling and control of flexible structures
p 28 N87-20564

BENTS, DAVID J.
Coaxial tube array space transmission line characterization
[NASA-TM-88864] p 96 N87-22003

BENZ, H. F.
A VHSIC general purpose processor
p 116 N87-29145

BENZINGER, L.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

BERG, H.-P.
Status of the RITA - Experiment on EURECA
[AIAA PAPER 87-0988] p 123 A87-38002

BERGAMASCHI, S.
On the dynamical stability of the space 'monorail'
p 148 A87-34047

BERGER, G.
A study of fluid transfer management in space
[FTMS-RPT-006] p 97 N87-28058
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-28260

BERGMANN, E. V.
Mass property estimation for control of asymmetrical satellites p 63 A87-52988

BERMAN, ALBERT
Space station power semiconductor package
[NASA-CR-180829] p 81 N87-28825

BERMAN, DOUGLAS
A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system
[AIAA PAPER 87-2467] p 77 A87-50511

BERNSTEIN, D. S.
Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741

BERNSTEIN, DENNIS S.
OPUS: Optimal Projection for Uncertain Systems
[AD-A178020] p 29 N87-21025

BERRY, ROBERT E.
Geostationary platforms - An international perspective
p 121 A87-32288

BERTOTTI, L.
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration
p 83 N87-28886

BERTRAM, A.
Dynamic qualification of spacecraft by means of modal synthesis p 28 N87-20383

BESNERS, G.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

BHANDARI, P.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145

BHANDARI, PRADEEP
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88295] p 79 N87-25836

BHAT, R. B.
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20589

BHATI, RAVINDER
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures
[NASA-CR-180317] p 38 N87-27280

BICHLER, U.
Intelligent flywheel energy storage units with additional functions for future space stations in near-earth orbits
[DGLR PAPER 86-172] p 57 A87-36782

BICKFORD, R. L.
Evaluation of carbon-carbon for space engine nozzle
p 98 N87-28116

BIED SPERLING, BARBRA
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 118 A87-33003

BIED, BARBRA
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724

BIGHAM, J.
Space Station Information System integrated communications concept
[AIAA PAPER 87-2228] p 114 A87-48806

BIGHAM, J., JR.
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2229] p 114 A87-48807

BIGNIER, MICHEL
Europe's future in space p 143 A87-32278

BILLINGS, W. W.
Power management equipment for space applications
[SAE PAPER 861621] p 74 A87-32578

BIRD, G. A.
Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 135 A87-43080

BIRD, J. O.
Evaluation of carbon-carbon for space engine nozzle
p 98 N87-28116

BIRNER, W.
Status of the RITA - Experiment on EURECA
[AIAA PAPER 87-0988] p 123 A87-38002

BISHOP, L. R.
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531

BISHOP, R. H.
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531

BJORKMAN, M. D.
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-29582

BLACK, DAVID C.
NASA's space program - Space Station: A status report and a view of its value for space science
p 1 A87-32277
A crisis in the NASA space and earth sciences programme p 112 A87-37988
Scientific customer needs - NASA user
[AIAA PAPER 87-2198] p 119 A87-48582

BLACKBURN, DAVID A.
Ideas for educational physics experiments in space
p 130 N87-25033

BLAIS, T.
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-28260

BLAND, TIMOTHY J.
Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 861826] p 41 A87-32882

BLANKENSHIP, G. L.
Modeling and control of flexible structures
[AD-A177108] p 29 N87-21388
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179726] p 35 N87-24517

BLELLOCH, P. A.
Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812

BLELLOCH, PAUL
Control/dynamics simulation for preliminary Space Station design
[AIAA PAPER 87-2841] p 61 A87-50488

BLOCK, ROGER F.
Automated Subsystem Control for Life Support System (ASCLSS)
[NASA-CR-172003] p 53 N87-29117

BLOOMFIELD, HARVEY
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88295] p 79 N87-25836

BLUME, HANS-JUERGEN C.
Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit
[NASA-TM-89118] p 86 N87-20339
Measurement apparatus and procedure for the determination of surface emissivities
[NASA-CASE-LAR-13455-1] p 29 N87-21208

BLUTH, B. J.
Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21886

BO, RONALD A.
An evaluation of advanced extravehicular crew enclosures
[SAE PAPER 861009] p 134 A87-38781

BOBO, PH.
SPOT solar array in-orbit deployment results evaluation p 83 N87-28886

BOCKRIS, JOHN OM.
Electrochemical processing of solid waste
[NASA-CR-181128] p 137 N87-25443

BODE, JOERG
Stress and deformation analysis of lightweight composite structures
[MBB-UD-488/86] p 30 N87-22289

BODECHTEL, J.
Land panel report p 128 N87-20634

BODLEY, CARL S.
Tethered satellite program control strategy
[AAS PAPER 86-221] p 123 A87-38570

BOER, M.
The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-38443

BOESIO, S.
Data management system architecture options for space stations
[SES/DMP/TR/002/85] p 115 N87-28585

BOFILIOS, D. A.
Vibrations and structureborne noise in space station
[NASA-CR-181281] p 39 N87-29580

BOLDEA, I.
Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-38735

BOND, A.
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015

BOOHER, CLETIS R.
Space Station personal hygiene study
[SAE PAPER 860931] p 163 A87-38721

BORDANO, ALDO
Space station control moment gyro control
p 64 N87-20669

BOSSI, J. A.
A laboratory simulation of flexible spacecraft control
[AIAA PAPER 87-2325] p 24 A87-50446

BOSTIC, SUSAN W.
A Lanczos eigenvalue method on a parallel computer
[AIAA PAPER 87-0725] p 13 A87-33585
Experiences with the Lanczos method on a parallel computer p 21 A87-41159

BOUQUET, F. L.
Spacecraft dielectric material properties and spacecraft charging p 105 A87-33100
Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-38843

BOUQUET, FRANK L.
Design considerations for long-lived glass mirrors for space p 123 A87-38531

BOURLAND, CHARLES T.
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720

BOURNE, GARRETT D.
Military space station implications
[AD-A180831] p 172 N87-29964

BOWLES, DAVID E.
Composite tubes for the Space Station truss structure
p 20 A87-38801

BOYDA, R. B.
EDC development and testing for the Space Station program
[SAE PAPER 860918] p 118 A87-38710
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733

BRACCIO, MATTHEW A.
Development of a standard connector for orbital replacement units for serviceable spacecraft
p 40 N87-29864

BRACHET, G.
Remote sensing applications: Commercial issues and opportunities for space station p 156 N87-20626

BRADLEY, OBIE H., JR.
Thermal design of the ACCESS erectable space truss
p 42 A87-34469

BRADY, JOYCE
An evaluation of candidate oxidation resistant materials for space applications in LEO
[NASA-TM-100122] p 107 N87-25480

BRAND, TIMOTHY J.
Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744

BRANDHORST, HENRY W., JR.
Alternative power generation concepts for space
p 81 N87-28881

BRANDT, G.
Evolution of data management systems from Spacelab to Columbus
[AIAA PAPER 87-2227] p 154 A87-48805

BRDAR, MARKO
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 131 N87-26188
BREITBACH, E.
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357
BRENNAN, SCOTT M.
Mixing-induced ullage condensation and fluid destratification
[AIAA PAPER 87-2018] p 92 A87-45357
Space station propulsion-ECLSS interaction study
[NASA-CR-175080] p 54 N87-29584
BRETHERTON, FRANCIS
A crisis in the NASA space and earth sciences programme p 112 A87-37966
BREWER, DANA A.
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration
[SAE PAPER 860916] p 47 A87-38708
Supercritical water oxidation - Concept analysis for evolutionary Space Station application
[SAE PAPER 860993] p 51 A87-38770
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53979
BREYLEY, LORANELL
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 62 A87-52252
BRILEY, G. L.
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1858] p 91 A87-45255
Space station propulsion test bed: A complete system
p 98 N87-26131
BRINZA, DAVID E.
Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38625
Proceedings of the NASA Workshop on Atomic Oxygen Effects
[NASA-CR-181163] p 141 N87-26173
Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26190
BRODSKY, R. F.
Trends in space transportation p 168 A87-41572
BRONOWICKI, ALLEN J.
Application of physical parameter identification to finite-element models p 34 N87-24505
BROOKS, GEORGE W.
The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary
[NASA-CR-178276] p 8 N87-21020
BROSSEL, KENNETH S.
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
BROWN, BLAISE W.
Real-time simulation for Space Station
p 7 A87-37298
BROWN, NORMAN S.
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1489] p 90 A87-43027
Advanced long term cryogenic storage systems
p 94 N87-21142
BROWN, ROBERT A.
A crisis in the NASA space and earth sciences programme p 112 A87-37966
BRUZZI, S.
Panel report on new approaches to calibration and validation p 157 N87-20638
BRYANT, TIMOTHY D.
Vapor fragrancer
[NASA-CASE-LAR-13680-1] p 165 N87-25561
BUCKALEW, V.
Space station momentum management
p 64 N87-20998
BUCKE, CHRIS
An evolutionary approach to the development of a CELSS based air revitalization system
[SAE PAPER 860968] p 49 A87-38750
BUCKNER, GERALD L.
The liquid droplet radiator in space: A parametric approach
[AD-A182805] p 46 N87-29217
BUDININKAS, P.
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860985] p 50 A87-38764
BUECKER, H.
The problem of radiation exposure in the Space Station
[DGLR PAPER 86-175] p 153 A87-48157
Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-49030
BUEHLER, KURT D.
Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11368-1] p 102 N87-25583
BUGAJSKI, DANIEL J.
Robust control of a large space antenna
[AIAA PAPER 87-2253] p 86 A87-50417
BUGG, FRANK M.
Space station structures and dynamics test program
p 33 N87-22751
BULLOCH, CHRIS
Space Station - All change? p 154 A87-50792
BUNNER, ALAN N.
Optical arrays for future astronomical telescopes in space p 126 A87-44533
BURCZIK, KLAUS
The GDR and the Soviet space program - The optical instrument sector of the GDR contributions
p 155 A87-53559
BURDETT, GERALD L.
The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53082
BURGESS, GREGG E.
Space Station tracking subsystem sensor evaluation
p 85 A87-45520
BURGESS, T. W.
Remote handling facility and equipment used for space truss assembly
[DE87-009121] p 103 N87-27408
BURKE, KEVIN C.
A crisis in the NASA space and earth sciences programme p 112 A87-37966
BURKE, SHAWN E.
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
BURKE, W. R.
Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-29959
BURNS, J. A.
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183302] p 11 N87-29860
BURNS, JOSEPH A.
A crisis in the NASA space and earth sciences programme p 112 A87-37966
BURTON, R. L.
Performance of an SP-100/pulsed electrothermal thruster orbit transfer vehicle
[AIAA PAPER 87-2027] p 77 A87-45363
BUSBY, M. S.
The benefit of phase change thermal storage for spacecraft thermal management
[AIAA PAPER 87-1482] p 43 A87-43014
BUSH, HAROLD G.
Design, construction, and utilization of a space station assembled from 5-meter erectable struts
p 34 N87-24501
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 103 N87-29118
BUSQUETS, A. M.
Electronic control/display interface technology
p 88 N87-29161
BUSSOLARI, STEVEN
Human factors in space station architecture 2. EVA access facility: A comparative analysis of 4 concepts for on-orbit space suit servicing
[NASA-TM-86856] p 52 N87-24064
BUTTERFIELD, A. J.
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340
BYUN, KUK WHAN
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502

C

CALEDONIA, GEORGE E.
A high flux pulsed source of energetic atomic oxygen
p 139 A87-38623
Pulsed source of energetic atomic oxygen
p 108 N87-26186
CALICO, R. A.
The effects of structural perturbations on decoupled control p 35 N87-25350
CALISE, A. J.
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0959] p 18 A87-33751
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
CALISE, ANTHONY J.
Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2568] p 136 A87-48818
Singular perturbation analysis of AOTV related trajectory optimization problems
[NASA-CR-180301] p 137 N87-29827
CAMPBELL, H.
Space station propulsion test bed: A complete system
p 98 N87-26131
CAMPBELL, ROY H.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412
CANFIELD, R.
ASTROS - A multidisciplinary automated structural design tool
[AIAA PAPER 87-0713] p 6 A87-33557
CANIZARES, CLAUDE R.
A crisis in the NASA space and earth sciences programme p 112 A87-37966
CARLOMAGNO, GIOVANNI M.
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
CARPER, RICHARD
Data capture and processing
[AIAA PAPER 87-2203] p 113 A87-48588
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443
CARRASQUILLO, E. A.
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132
CARROLL, JOSEPH A.
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40510
CARROLL, MONTY B.
An electromechanical attenuator/actuator for Space Station docking p 138 N87-29879
CARROLL, THOMAS W.
The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29865
CARSON, MAURICE A.
Space Station EVA systems trade-off model
[SAE PAPER 860980] p 134 A87-38767
CASSISA, G. C.
The hardware/software architecture of the Columbus pressurized module element
[AIAA PAPER 87-2211] p 154 A87-48586
CASTELLANI, ANTONIO
Effect of modal damping in modal synthesis of spacecraft structures p 28 N87-20362
CASWELL, DOUGLAS
The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 100 A87-41153
CATANI, J. P.
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit
p 158 N87-29953
CAUGHEY, T. K.
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711
CAUGHEY, THOMAS
Vibration suppression by stiffness control
p 66 N87-22730
CAVALLARO, JOSEPH N.
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179108] p 161 N87-23677
CAWOOD, G. W.
Evaluation of carbon-carbon for space engine nozzle
p 98 N87-26116
CENCICH, TOM
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21887
CERZA, M. R., JR.
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32686
CHALMERS, D. R.
Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32683
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103
CHAMBERLIN, DAVID N.
Measuring thermal expansion in large composite structures p 20 A87-38812

CHAN, JOHN D.

An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A179235] p 68 N87-23681

CHAPMAN, J. M.

Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33709

Dynamics of trusses having nonlinear joints
p 32 N87-22724

Equivalent beam modeling using numerical reduction techniques p 32 N87-22725

CHARON, W.

Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-64/85] p 35 N87-24516

CHEN, CHUNG-WEN

Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2387] p 24 A87-50471

Projection filters for modal parameter estimate for flexible structures
[NASA-CR-180333] p 38 N87-26583

CHEN, G.

Modeling, stabilization and control of serially connected beams p 21 A87-41052

CHEN, ING-YOUN

Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 861826] p 41 A87-32662

CHEN, J. C.

Structural dynamics system model reduction
p 32 N87-22727

System identification for large space structure damage assessment p 33 N87-22750

CHEN, J.-C.

Structural control by the use of piezoelectric active members p 69 N87-24509

CHEN, JAY

Vibration suppression by stiffness control
p 66 N87-22730

CHEN, JAY C.

Verification of large beam-type space structures
p 31 N87-22712

CHEN, JAY-C.

On the control of structures by applied thermal gradients p 33 N87-22747

CHEN, JAY-CHUNG

On orbit damage assessment for large space structures
[AIAA PAPER 87-0870] p 15 A87-33834

On sine dwell or broadband methods for modal testing
[AIAA PAPER 87-0881] p 18 A87-33752

CHENG, U.

GPS applications to the Space Station
p 138 A87-45525

CHESNEY, JAMES

Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48587

CHETTY, P. R. K.

New power processor interfaces MMS power module outputs p 77 A87-48264

CHEVERS, EDWARD S.

Space Station integration and verification concepts
p 84 A87-31461

CHIE, CHAK-MING

FDMA system design and analysis for Space Station
p 85 A87-45483

CHIEN, S.

Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4081] p 53 N87-26088

CHIOU, J. C.

Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33728

CHOI, C. S.

Dynamic finite element modeling of flexible structures
[AD-A177168] p 30 N87-22252

CHOI, KYUNG K.

Shape design sensitivity analysis and optimal design of structural systems
[NASA-CR-181095] p 37 N87-26370

CHOW, E.

Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145

CHOW, EDWIN

Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89295] p 79 N87-25839

CHRISTENSEN, E. R.

Dynamic finite element modeling of flexible structures
[AD-A177168] p 30 N87-22252

CHRISTIAN, E. L.

Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1540] p 44 A87-44843

CHROSTOWSKI, J. D.

MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32639

A computer program for model verification of dynamic systems p 31 N87-22710

CHU, F. H.

Application of reanalysis techniques in dynamic analysis of spacecraft structures p 21 A87-38824

CHU, JAMES

Phase change water recovery for Space Station - Parametric testing and analysis
[SAE PAPER 860986] p 51 A87-38765

CHU, QI PING

Maximum likelihood parameter identification of flexible spacecraft
[ETN-87-90235] p 38 N87-27705

CHUBB, DONALD L.

Liquid sheet radiator
[AIAA PAPER 87-1525] p 43 A87-43048

Performance characteristics of a combination solar photovoltaic heat engine energy converter
[NASA-TM-89808] p 78 N87-23029

CHULLEN, CINDA

Pre- and post-treatment techniques for spacecraft water recovery
[SAE PAPER 860982] p 50 A87-38761

CHUNG, SHIRLEY Y.

Degradation studies of SMRM teflon
p 106 A87-38641

O-atom degradation mechanisms of materials
p 141 N87-26178

CHURCH, S. M.

Experimental characterization of deployable trusses and joints p 33 N87-22749

CHUTJIAN, ARA

Variable energy, high flux, ground-state atomic oxygen source
[NASA-CASE-NPO-16640-1-CU] p 8 N87-21881

CIMINO, JOBEA

The Earth Observing System (EOS) synthetic aperture radar (SAR) p 128 A87-44167

CINTALA, MARK J.

Experimentation in planetary geology
p 124 A87-40319

CIOCCA, JOSEPH A.

Evaluation of regenerative portable life support system options
[SAE PAPER 860948] p 48 A87-38735

CLARK, WALTON

Communication and Data Management Systems for an orbiting platform p 112 A87-40359

CLASS, BRIAN F.

Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32736

CLEARWATER, SCOTT

Radiation shielding requirements on long-duration space missions
[AD-A177512] p 140 N87-21991

CLEVENSON, SHERMAN A.

Documentation of the space station/aircraft acoustic apparatus
[NASA-TM-89111] p 140 N87-20795

CLIFF, E. M.

Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183302] p 11 N87-29893

CLODFELTER, KEN

Hydrogen-oxygen thruster with no products of combustion in exhaust plume
[AIAA PAPER 87-1775] p 91 A87-45106

CLOPP, WILLIAM

An advanced geostationary communications platform
p 125 A87-43165

COCHRAN, J. E., JR.

Analytical solutions for static elastic deformations of wire ropes
[AIAA PAPER 87-0720] p 6 A87-33561

Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180898] p 29 N87-20569

Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22708

A new approach for vibration control in large space structures p 33 N87-22743

COCHRAN, THOMAS H.

Space station electrical power system
[NASA-TM-100140] p 80 N87-28144

COHEN, H. A.

Automatic charge control system for geosynchronous satellites p 87 N87-25960

COHEN, MARC M.

Human factors in space station architecture 2. EVA access facility: A comparative analysis of 4 concepts for on-orbit space suit servicing
[NASA-TM-86856] p 52 N87-24064

COHEN, S. A.

Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26200

COLE, R. K.

The Vanderbilt University neutral O-beam facility
p 105 A87-32058

COLEMAN, MARK

Liquid propulsion technology for expendable and STS launch vehicle transfer stages
[AIAA PAPER 87-1934] p 92 A87-45211

COLES-HAMILTON, CAROLYN

Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-89886] p 78 N87-22174

COLIZZI, E.

Infrared test technique validation on the Olympus satellite
[SAE PAPER 860939] p 150 A87-38729

COLOMBO, GERALD V.

Pre- and post-treatment techniques for spacecraft water recovery
[SAE PAPER 860982] p 50 A87-38761

COLWELL, GENE T.

Evaluation of Space Station thermal control techniques
[SAE PAPER 860998] p 42 A87-38775

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181009] p 45 N87-26072

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-26608

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702

COMPOSTIZO, C.

Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26280

CONLEY, G.

Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002

CONRAD, P.

Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363

COOK, EARL L.

Process control and data acquisition for commercial materials processing in space
[AIAA PAPER 87-2197] p 113 A87-48583

COOPER, PAUL A.

Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731

Interdisciplinary analysis procedures in the modeling and control of large space-based structures
p 22 A87-42679

Dual keel space station control/structures interaction study p 67 N87-22737

CORNWELL, PHILLIP J.

Localization of vibrations in large space reflectors
[AIAA PAPER 87-0949] p 18 A87-33745

CORONADO, A. R.

Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-29581

COSTA, S. RICHARD

The Consultative Committee for Space Data Systems Standards program
[AIAA PAPER 87-2204] p 113 A87-48589

COTTS, D. B.

Spacecraft dielectric material properties and spacecraft charging p 105 A87-33100

COULTER, DANIEL R.

Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38625

O-atom degradation mechanisms of materials
p 141 N87-26179

Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26180

COVAULT, CRAIG

Space Station EVA simulation demonstrates orbital assembly p 132 [illegible]

International cooperation in space
p 149 A87-34514

COX, KENNETH J.
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295
COYNER, J. V.
Box truss antenna technology status p 67 N87-24503
CRAIG, ROY R., JR.
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739
CRAVEN, P. D.
Potential modulation on the SCATHA spacecraft p 138 A87-34480
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft [AD-A178815] p 140 N87-21024
CRAWLEY, E. F.
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures p 21 A87-40075
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station [NASA-CR-4068] p 36 N87-25806
CRAWLEY, EDWARD F.
Material damping in aluminum and metal matrix composites p 108 A87-48797
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement p 84 N87-21147
Development of intelligent structures using finite control elements in a hierarchic and distributed control system [AD-A178711] p 72 N87-25805
CREAMER, NELSON G.
An identification method for flexible structures [AIAA PAPER 87-0745] p 16 A87-33660
CREMA, LUIGI BALIS
Effect of modal damping in modal synthesis of spacecraft structures p 26 N87-20362
CRESSEE, M. T.
The use of electric propulsion on low earth orbit spacecraft [AIAA PAPER 87-0989] p 68 A87-38003
CRISWELL, DAVID R.
Planning for space robotics developments and applications p 135 A87-40377
CROLEY, D.
Potential modulation on the SCATHA spacecraft p 138 A87-34480
CROLEY, D. R., JR.
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft [AD-A178815] p 140 N87-21024
CROOP, HAROLD C.
Development of precision structural joints for large space structures p 28 N87-20374
CROSS, J. B.
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 105 A87-32080
Mass spectrometers and atomic oxygen p 141 N87-26176
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-26186
CUCCIA, C. LOUIS
The evolution of the geostationary platform concept p 125 A87-43154
CUDDIHY, W. F.
An advanced technology space station for the year 2025, study and concepts [NASA-CR-178208] p 120 N87-20340
CULP, ROBERT D.
Guidance and control 1986; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 1-5, 1986 p 55 A87-32726
CURRAN, P. J.
A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K. p 125 A87-41430
CURTIS, ROBERT L.
Habitability issues for the Science Laboratory Module [SAE PAPER 860871] p 50 A87-38753
CURTIS, S. B.
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-48026
CURTIS, SALLY
Characterization and hardware modification of linear momentum exchange devices [NASA-TM-88884] p 70 N87-24723
CUSICK, ROBERT J.
An advanced carbon reactor subsystem for carbon dioxide reduction [SAE PAPER 860995] p 51 A87-38772
CUTCHINS, M. A.
Initial investigations into the damping characteristics of wire rope vibration isolators [NASA-CR-180090] p 29 N87-20569
CVETANOVIC, R. J.
Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-26179
CYROT, D. N.
Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25358
CZAJKOWSKI, EVA A.
Spillover stabilization and decentralized modal control of large space structures [AIAA PAPER 87-0903] p 17 A87-33712

D

D'ELEUTERIO, G. M. T.
Dynamics of gyroelastic spacecraft p 59 A87-47811
DABROWSKI, DAVID
Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system [SAE PAPER 860999] p 43 A87-38776
DAECH, A. F.
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-26181
DAHLGREN, J. B.
Control technology overview in CSI p 69 N87-24507
DALEY, S.
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
DALTON, JOHN
Data storage systems technology for the Space Station era [AIAA PAPER 87-2202] p 113 A87-48587
Mass storage systems for data transport in the early space station era 1992-1998 [NASA-TM-87826] p 115 N87-27443
DANIEL, P. L.
A spline-based parameter and state estimation technique for static models of elastic surfaces [NASA-CR-180449] p 11 N87-30107
DARBHAMULLA, SIVA PRASAD
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures [NASA-CR-180317] p 38 N87-27280
DARMS, FRED J.
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results [AIAA PAPER 87-2157] p 160 A87-45441
DAROOKA, D. K.
A transient analysis of phase change energy storage system for solar dynamic power [AIAA PAPER 87-1489] p 77 A87-43004
DAVIES, D. K.
Radiation charging and breakdown of insulators p 143 N87-26954
DAVIES, JOHN K.
Infra-red astronomy after IRAS p 127 A87-54197
DAVIS, L. P.
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22729
DAVIS, M. H.
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations [NASA-CP-2460] p 84 N87-20885
DAVIS, ROBERT A.
Technology projections and space systems opportunities for the 2000-2030 time period [AAS PAPER 86-106] p 2 A87-53066
DAVIS, V. A.
Ram ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51712
DE LUCA, LUIGI
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
DEACETIS, LOUIS A.
Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-26888
DEAN, D. J.
The Vanderbilt University neutral O-beam facility p 106 A87-32058
DEBROCK, S. C.
On-orbit assembly and repair p 135 A87-40376
DECARLIS, JAMES J., JR.
Energy expenditure during simulated EVA workloads [SAE PAPER 860921] p 163 A87-38713
DEFELICE, DAVID M.
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [AIAA PAPER 87-1764] p 92 A87-48572
Cryogenic Fluid Management Flight Experiment (CFMFE) p 95 N87-21150
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [NASA-TM-89921] p 96 N87-22949
DEININGER, W.
Nuclear reactor power for an electrically powered orbital transfer vehicle [AIAA PAPER 87-1102] p 76 A87-41145
DEININGER, WILLIAM
Nuclear reactor power for a space-based radar. SP-100 project [NASA-TM-89295] p 79 N87-25838
DEKANS, J.
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 82 N87-29873
DELAFUENTE, E.
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE) [ESA-CR(P)-2347] p 103 N87-28280
DELAPLACE, JEAN
ERATO orbital transfer vehicle with electronuclear power Study of the associated electronuclear generator p 75 A87-38844
DELFOUR, M. C.
Modeling, stabilization and control of serially connected beams p 21 A87-41052
DELIL, A. A. M.
Quality monitoring in two-phase heat transport systems for large spacecraft [SAE PAPER 860958] p 42 A87-38743
DEMEIS, RICHARD
Mir - A second Sputnik? p 153 A87-46872
DEMING, DOUGLAS R.
Rendezvous and docking tracker [AAS PAPER 86-014] p 133 A87-32730
DER, JAMES J.
Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation [AIAA PAPER 87-2021] p 92 A87-45380
DERBY, EDDY A.
Measuring thermal expansion in large composite structures p 20 A87-38812
DERBYSHIRE, KEITH
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32346
DES JARDINS, R.
Data management standards for space information systems [AIAA PAPER 87-2205] p 113 A87-48580
DETTLAFF, K.
Aerospatiale solar arrays, in orbit performance p 159 N87-29899
DEVANCE, DARRELL
Space station power semiconductor package [NASA-CR-180829] p 81 N87-28825
DEVER, TERESE
An evaluation of candidate oxidation resistant materials p 110 N87-26203
DEVER, THERESE
An evaluation of candidate oxidation resistant materials for space applications in LEO [NASA-TM-100122] p 107 N87-25480
DEVILLIERS, D.
The orbit configuration panel report p 157 N87-20640
DEVILLIERS, N.
Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 129 N87-20625
Orbit configurations p 156 N87-20629
DIARRA, CHEICK M.
The dynamics and control of large flexible space structures X, part 1 [NASA-CR-181287] p 73 N87-27712
DIETZ, REINHOLD H.
Space Station communications and tracking system p 134 A87-37297
DIFILIPPO, FRANK
An evaluation of candidate oxidation resistant materials for space applications in LEO [NASA-TM-100122] p 107 N87-25480
An evaluation of candidate oxidation resistant materials p 110 N87-26203
DIPIRRO, MICHAEL J.
Superfluid helium on orbit transfer (SHOOT) p 95 N87-21151
DOANE, G. B., III
Distributed control using linear momentum exchange devices [NASA-TM-100308] p 70 N87-24521

DOBLAS, F.
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26280

DOLKAS, PAUL C.
Special considerations in outfitting a space station module for scientific use
[SAE PAPER 860956] p 164 A87-28741

DONATO, MARC
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-46882

DONCHIN, EMANUEL
Workshop on Workload and Training, and Examination of their Interactions: Executive summary
[NASA-TM-89458] p 171 N87-25780

DONG, EDWARD V.
On board Data Management p 112 A87-40381

DONOHOE, MARTIN J.
Earth resources instrumentation for the Space Station Polar Platform p 126 A87-44184

DORR, LES, JR.
When the doctor is 200 miles away
p 47 A87-29800

DOUGHERTY, H. J.
Vibration isolation for line of sight performance improvement p 67 N87-22742

DOURA, T.
Japanese data relay satellite system
[AIAA PAPER 87-2188] p 154 A87-49585

DOW, JOHN O.
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33584

DRABBEY, S.
Modal testing of the Olympus development model stowed solar array p 27 N87-20388

DREER, THOMAS
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532

DUCHOSSOIS, G.
USA-Europe coordination and cooperation activities: Announcements of Opportunity p 170 N87-20832
Panel report on multidisciplinary instrumentation: New possibilities p 161 N87-20837

DUCK, B. J.
Surface modification to minimise the electrostatic charging of Kapton in the space environment
p 87 N87-26958

DUFRANE, KEITH
Space Station lubrication considerations
p 104 N87-29879

DUNN, KEVIN W.
Space station data management system - A common GSE test interface for systems testing and verification
p 112 A87-37294

DURAN, J. B.
The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178182] p 9 N87-21886

DURCANIN, J. T.
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103

DUROCHER, CORT L.
National space transportation studies
[SAE PAPER 861681] p 160 A87-32508

DURRETT, JOHN C.
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DUBOIS, N.
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707
Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2381-VOL-4] p 73 N87-27708

DWYER, THOMAS A. W., III
Variable structure controller design for spacecraft rotation damping p 58 A87-38858
Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2585] p 62 A87-50581

E

EAGLESON, KENNETH W.
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-40068

EBARA, KATSUYA
Water recycling system using thermopervaporation method p 46 A87-32458
Water recycling for Space Station p 46 A87-32459

EBERHARDT, RALPH N.
On-orbit fluid management p 132 A87-32543

ECK, T. G.
Oxygen interaction with space-power materials
[NASA-CR-181368] p 132 N87-29833

ECKARDT, THOMAS
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532

ECKHARDT, K.
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 38 N87-26075

EDBERG, D. L.
On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0887] p 16 A87-33708

EDBERG, DON
On the control of structures by applied thermal gradients p 33 N87-22747

EDBERG, DONALD L.
Control of flexible structures by applied thermal gradients p 21 A87-39543

EDELSON, BURTON I.
The evolution of the geostationary platform concept
p 125 A87-43154

EDELSTEIN, FRED
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125

EDGESON, GEORGE D.
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-89084] p 70 N87-24723

EDIGHOFFER, HAROLD H.
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0888] p 15 A87-33833
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41613
Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178288] p 10 N87-24709

EGRY, I.
Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2195] p 153 A87-48581

EGUCHI, RISAO
Japanese experiment module data management and communication system p 147 A87-32542

EIKE, DAVID
SOT: A rapid prototype using TAE windows
p 114 N87-23181

EIKE, DAVID R.
User interface design guidelines for expert troubleshooting systems p 6 A87-33050

EKE, FIDELIS O.
On the inadequacies of current multi-flexible body simulation codes
[AIAA PAPER 87-2248] p 7 A87-50412

ELLIS, R. C.
Common drive unit p 104 N87-29868

ELZEKI, B.
Modal testing of the Olympus development model stowed solar array p 27 N87-20388

EMANUEL, ERVIN M.
Space station electrical power distribution analysis using a load flow approach p 80 N87-28889

EMERY, A. F.
Radiation heat transfer calculations for space structures
[AIAA PAPER 87-1522] p 44 A87-44830

ENDRES, B. B.
Composite space antenna structures - Properties and environmental effects p 20 A87-38810

ENGEL, ALBERT G.
Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744

ENGELS, REED C.
A general method for dynamic analysis of structures overview p 31 N87-22707

ENGLISH, ROBERT E.
Speculations on future opportunities to evolve Brayton powerplants aboard the space station
[NASA-TM-88983] p 121 N87-23874

ENNIS, KIMBERLY A.
Liquid propulsion technology for expendable and STS launch vehicle transfer stages
[AIAA PAPER 87-1934] p 82 A87-45211

ERBEN, E.
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 38 N87-26075

ERICKSON, ALBERT C.
Space Station life support oxygen generation by SPE water electrolyzer systems
[SAE PAPER 860943] p 49 A87-26738

ERICKSON, C. M.
Concepts for space maintenance of OTV engines
p 135 A87-41181
Concepts for space maintenance of OTV engines
p 136 A87-48030
Concepts for space maintenance of OTV engines
p 137 N87-29097

ERICKSON, JON D.
Manned spacecraft automation and robotics
p 100 A87-37300

ERWIN, HARRY O.
Laser docking system flight experiment
[AAS PAPER 86-043] p 99 A87-32745

ESPARS, D.
Survey of solar-dynamic space power - The Stirling option p 77 A87-42265

ESTES, JOHN E.
Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817

ESTES, ROBERT D.
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180622] p 129 N87-22509
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-28581

EVANGELIDES, J. S.
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182501] p 110 N87-26709

EVERMAN, M. R.
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 38 N87-25808

EVERMAN, MICHAEL R.
Space Station alpha joint bearing p 83 N87-29882

EWELL, R.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145

EWELL, RICHARD
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89096] p 79 N87-25839

EZAWA, NAOYA
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547

F

FACIUS, R.
Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-49030

FAGET, MAXIME A.
The Industrial Space Facility p 167 A87-38579

FAGOT, CATHERINE
Physiological requirements and pressure control of a spacesuit
[SAE PAPER 860985] p 150 A87-38747

FANSON, J. L.
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711
Structural control by the use of piezoelectric active members p 69 N87-24509

FANSON, JAMES
Vibration suppression by stiffness control
p 68 N87-22730

FANSON, JAMES L.
An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-26807

FARADAY, BRUCE J.
Testing of materials for solar power space applications p 107 A87-53846

FARINA, F.
Organic Rankine cycle power conversion systems for space applications p 159 N87-29888

FARMER, JEFFERY T.
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89127] p 45 N87-21021

FARRANCE, MICHELLE A.
Space Station - The next logical step
p 169 A87-47888

FEDOR, J. V.
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25353

FELDMAN, L. A.
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182931] p 110 N87-25709
FENNELL, J.
Potential modulation on the SCATHA spacecraft
p 138 A87-34480
FENNELL, J. F.
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A178815] p 140 N87-21024
FEREBEE, MELVIN J., JR.
Optimization of payload mass placement in a dual keel space station
[NASA-TM-89051] p 68 N87-23887
FESMIRE, JAMES E.
Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11369-1] p 102 N87-25583
FESTER, DALE A.
On-orbit fluid management p 132 A87-32543
FETTERMAN, TIMOTHY L.
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures
[NASA-CR-4068] p 40 N87-25886
FEURBACHER, B.
Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2195] p 153 A87-48681
FICHTEL, CARL E.
High energy gamma ray astronomy
p 129 N87-24258
FIELDS, SUSAN T.
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-26583
FINK, R. A.
Common drive unit p 104 N87-26889
FINLEY, J. A.
Preliminary evaluation of a reaction control system for the space station p 67 N87-22736
FINZI, AMALIA ERCOLI
Active structural controllers emulating structural elements by ICUs p 27 N87-20357
Automatic docking manoeuver and attitude control system p 71 N87-25385
FISCHER, H.
Report of the atmosphere panel p 161 N87-20833
FISCHER, JAMES C.
Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25560
FISHER, H. T.
On-orbit assembly and repair p 135 A87-40376
FISHER, ROBERT R.
Optimal shuttle attitude changes using tethers
[AD-A178205] p 129 N87-22758
FITZ-COY, N. G.
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180089] p 28 N87-20589
Space Station/Shuttle Orbiter dynamics during docking p 65 N87-22709
FLAMENT, P.
Computer simulation of deployment
p 10 N87-29002
FLANDERS, HOWARD A.
Tethered satellite program control strategy
[AAS PAPER 86-221] p 123 A87-38570
FLEETER, S.
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 168 A87-25398
FLEGER, STEPHEN A.
User interface design guidelines for expert troubleshooting systems p 8 A87-33050
FLORES, C.
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration
p 83 N87-26886
FLUGEL, CHARLES
Maintenance evaluation for space station liquid systems p 52 N87-21155
FOGLEMAN, GORDON V.
Habitability issues for the Science Laboratory Module
[SAE PAPER 860871] p 50 A87-38753
FONG, MICHAEL C.
External contamination environment of Space Station Customer Servicing Facility
[AIAA PAPER 87-1623] p 52 A87-43122
FONTANA, ANTHONY
Status of the Mast experiment p 30 N87-22703
FORTEZZA, R.
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments
p 151 A87-38836
FORTINI, ANTHONY
Mixing-induced ullage condensation and fluid destratification
[AIAA PAPER 87-2018] p 92 A87-45357
FORTINI, ANTHONY F.
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
FOSS, RICHARD A.
Thermal design of the ACCESS erectable space truss
p 42 A87-34489
FOUDRIAT, EDWIN C.
Distributed computer taxonomy based on O/S structure p 116 N87-29127
FOUNDS, DAVID
Joint Optics Structures Experiment (JOSE)
p 34 N87-24497
FOURNIER-SICRE, A. P.
A model for the estimation of the operations and utilisation costs of an international space station
p 168 A87-42267
FOURNET, J. B.
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit
p 139 N87-26853
FOWLER, B. L.
Experimental characterization of deployable trusses and joints p 33 N87-22749
FOX, D. A.
Power management equipment for space applications
[SAE PAPER 861621] p 74 A87-32576
FRANKLIN, S. BRUCE
End-to-end communications for Space Station
p 86 A87-45522
FREDERICKSON, A. R.
Spacecraft dielectric material properties and spacecraft charging p 105 A87-33100
FREELAND, R. E.
Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24508
FREEMAN, JANET S.
Design considerations for a one-kilometer antenna stick
[AIAA PAPER 87-0871] p 15 A87-33835
FREMAN, A. B.
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32815
Critical length for stable elongated orbiting structures
p 148 A87-32819
FRIEDMAN, ROBERT
Fire safety concerns in space operations
[NASA-TM-89848] p 165 N87-20342
FRIBOUT, D.
Microgravity experiments onboard Eureca
p 155 A87-53554
FUENTES, M.
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26260
FUJII, HARUHISA
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32388
FUJII, HIRONORI
The mission function control for deployment and retrieval of subsatellite
[AIAA PAPER 87-2326] p 126 A87-50447
FUJIMORI, HIROAKI
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32458
FUJIMORI, YOSHINORI
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32540
Evaluation testing of a mechanical actuator component operating in a simulated space environment
p 160 A87-32548
FUJITA, MASAHARU
Observation of precipitation from space by the weather radar p 145 A87-32507
FUJITA, T.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145
FUJITA, TOSHIO
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89295] p 79 N87-25838
FUJIWARA, TERUO
A consideration to vibration control for a large space structures p 54 A87-32441
FUJIWARA, Y.
Japanese customer needs for Space Station
[AIAA PAPER 87-2183] p 153 A87-48680
FUKUDA, TOSHIO
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Vibration control for a linked system of flexible structures p 55 A87-32444
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel
p 55 A87-32448
Control of a flexible space manipulator
p 89 A87-32449
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50033
FUKUNAGA, HISAO
Tailored laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794
FULTON, ROBERT E.
A Lanczos eigenvalue method on a parallel computer
[AIAA PAPER 87-0725] p 13 A87-33585
Experiences with the Lanczos method on a parallel computer p 21 A87-41159
FUNK, JOAN G.
Assessment of space environment induced microdamage in toughened composite materials
p 20 A87-38809
FURITOVA, I. I.
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735
FURR, PAUL A.
Physiological aspects of EVA
[SAE PAPER 860921] p 164 A87-38768
FURUKAWA, MASAO
Development of fluid loop system for spacecraft
p 144 A87-32370
FURUYA, HIROSHI
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341

G

GAHN, RANDALL F.
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell
[NASA-TM-100102] p 79 N87-24828
GAI, ELIEZER
On the performance analysis of a real-time distributed computer system p 111 A87-31518
GALLOWAY, WILLIAM E.
Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms
[AAS PAPER 86-041] p 130 A87-32743
GAMBERALE, R.
Data management system architecture options for space stations
[SES/DNP/TR/002/85] p 115 N87-26886
GANESKOTA, KAPAL
An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579
GANSVIND, I. N.
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801
GARAS, ANTHONY G.
Star topology spacecraft data bus
p 112 A87-37431
GARBA, J.
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33755
GARBA, J. A.
System identification for large space structure damage assessment p 33 N87-22750
GARBA, JOHN A.
On orbit damage assessment for large space structures
[AIAA PAPER 87-0870] p 15 A87-33834
Verification of large beam-type space structures
p 31 N87-22712
GARCIA, KATHY D.
Computer simulation of on-orbit manned maneuvering unit operations
[SAE PAPER 861783] p 47 A87-32832
GARCIA, RAFAEL
Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 50 A87-38762
GARLICK, GEORGE F. J.
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424
GARMAN, JOHN R.
The Space Station software support environment - Not just what, but why
[AIAA PAPER 87-2208] p 114 A87-48593
GARN, P. A.
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340

GARNIER, CH.
Dynamic modeling and optimal control design for large flexible space structures p 26 N87-20358
GARRISON, JAMES
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna
[NASA-TM-89137] p 45 N87-21021
GARRISON, P. W.
Advanced propulsion activities in the USA
p 90 A87-41575
GARVEY, J. M.
Space Station options for constructing advanced solar sails capable of multiple Mars missions
[AIAA PAPER 87-1902] p 91 A87-45267
GATEWOOD, G. D.
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222
GAVIT, SARAH A.
Orbital modifications using forced tether-length variations p 124 A87-40858
GAZENKO, O. G.
Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732
GEHLING, R. N.
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371
GEHLING, RUSSELL N.
Low-authority control through passive damping
[AAS PAPER 86-004] p 55 A87-32730
GEIGER, J. D.
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-26582
GENOVESE, J. E.
Thermal design of a large spacecraft propulsion system
[AIAA PAPER 87-1863] p 44 A87-45258
GERHOLD, CARL H.
Active vibration control in microgravity environment
p 72 N87-26700
GERLACH, LOTHAR
Improved solar generator technology for the EURECA low Earth orbit p 159 N87-26874
GIANNOVARIO, J. A.
Science Research Facilities - Versatility for Space Station
[SAE PAPER 860958] p 119 A87-38742
GIBBINS, M. N.
Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-26581
GIBSON, J. S.
Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32657
Adaptive identification of flexible structures by lattice filters
[AIAA PAPER 87-2458] p 24 A87-50504
GILBERT, DAVID W.
System level verification applying the Space Shuttle experience to the Space Station
[AAS PAPER 86-001] p 55 A87-32727
GILL, K. F.
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
GILLAN, DOUGLAS J.
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720
GIRTY, C. A.
Composite space antenna structures - Properties and environmental effects p 20 A87-38810
GIRARD, A.
Low frequency vibration testing on satellites
p 27 N87-20384
GIVENS, JOHN J.
An astrometric facility for planetary detection on the Space Station p 127 A87-50750
An astrometric facility for planetary detection on the space station
[NASA-TM-89438] p 128 N87-20841
GLAESE, JOHN R.
Contact dynamics math model
[NASA-CR-179147] p 71 N87-25801
GLASER, H.
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 36 N87-26075
GLASER, R. J.
Validation of large space structures by ground tests
p 11 A87-32336
Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-20581
GLASS, B. J.
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
GLEIM, DEAN
An electromechanical attenuator/actuator for Space Station docking p 138 N87-29879
GLUCK, R.
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0901] p 19 A87-34701
GODFREY, ROBERT D.
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel
p 113 A87-45485
GODWARD, J. L.
Thermal design of a large spacecraft propulsion system
[AIAA PAPER 87-1863] p 44 A87-45258
GOEL, P. S.
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25356
GOLDBERG, MICHAEL J.
Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-22457
GOLUB, MORTON A.
Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-26197
GONZALO, R.
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26260
GOO, S. D.
Environmental avoidance concepts for steerable Space Station radiators
[SAE PAPER 861831] p 41 A87-32665
GOPALAN, A. U.
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-29008
GOPIKANTH, M. L.
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712
GORDON, T.
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4091] p 53 N87-26366
GORIN, BARNEY F.
Refueling satellites in space - The OSCRS program
[SAE PAPER 861797] p 98 A87-32645
Operation of the orbital spacecraft consumables resupply system (OSCRS) at the Space Station
[AIAA PAPER 87-1766] p 135 A87-45182
GORKAVYI, N. N.
Critical length for stable elongated orbiting structures
p 148 A87-32819
GORSKI, RAYMOND J.
National space transportation studies
[SAE PAPER 861691] p 160 A87-32598
GOSSAIN, DEV
The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 100 A87-41153
GOULD, G. J.
On-orbit assembly and repair p 135 A87-40376
GRAFTON, JOSEPH E.
Hydrogen/oxygen economy for the space station
p 98 N87-26130
GRAHAM, WILLIAM R.
Control operations in advanced aerospace systems
p 54 A87-32117
GRAN, R.
Comparison of different attitude control schemes for large communications satellites
[AIAA PAPER 87-2381] p 61 A87-50475
GRANDHI, R. V.
Structural optimization with frequency constraints
[AIAA PAPER 87-0767] p 13 A87-33588
Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737
GRANT, TERRY
Advanced local area network concepts
p 117 N87-29153
GRANTHAM, WALTER J.
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2484] p 93 A87-50507
GRANTHAM, WILLIAM L.
Controls-structures-electromagnetics interaction program p 69 N87-24502
GRAY, ROBERT J.
Space suit reach and strength envelope considerations
[SAE PAPER 860950] p 49 A87-38737
GRECHKO, G. M.
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801
GRECZYN, WARREN G.
A proposal for space tether damage indication, location, and evaluation - The Repair Monkey Module
p 125 A87-43354
GREELEY, S. W.
Reduced-order compensation - LQG reduction versus optimal projection
[AIAA PAPER 87-2388] p 61 A87-50472
GREELEY, SCOTT W.
Active damping control design for the COFS Mast Flight System
[AIAA PAPER 87-2321] p 23 A87-50442
GREEN, B. D.
Chemical interactions in Low Earth Orbit (LEO)
p 109 N87-26186
GREEN, JERRY
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-46882
GREENBERG, JOEL S.
Leadership in space transportation
p 170 A87-53959
GREENE, JOHN B., JR.
Maintenance components for Space Station: long life fluid systems
[SAE PAPER 861005] p 89 A87-38778
GREGORY, J. C.
Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment
p 108 N87-26177
GRILIKHES, VLADIMIR ALEKSANDROVICH
Solar power satellites p 152 A87-44683
GRISHIN, SERGEI
Power plants in space p 155 A87-53580
GRONET, M. J.
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 38 N87-25808
GRONET, MARC J.
COFS 3 multibody dynamics and control technology
p 69 N87-24506
GROSS, DAVID W.
Development of a standard connector for orbital replacement units for serviceable spacecraft
p 40 N87-29864
GROSSI, MARIO D.
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-29581
GROSSMAN, M.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145
GROSSMAN, MERLIN
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89295] p 79 N87-25838
GROTE, M. G.
Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860979] p 42 A87-38760
GRUBER, ROBERT P.
Resistojet control and power for high frequency ac buses
[AIAA PAPER 87-0994] p 58 A87-41103
Resistojet control and power for high frequency ac buses
[NASA-TM-88960] p 63 N87-20477
GRUSZCZYNSKI, M. J.
Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1506] p 180 A87-43001
GUASTAFERRO, ANGELO
Space Station - The next logical step
p 169 A87-47888
GUERIN, B.
Study of expert system applications to space projects
[NE-51-887] p 115 N87-28057
GUERRIERO, LUCIANO
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 123 A87-38867
GUPTA, AMITAVA
Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38825
Degradation studies of SMRM teflon
p 108 A87-38841
O-atom degradation mechanisms of materials
p 141 N87-26178
Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26180
GUROVSKIY, N. N.
Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732

GUSTAFSON, ERIC
Space station active thermal control system modelling
[AIAA PAPER 87-1466] p 43 A87-43003
GUSTAN, EDITH
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-36740
GUSTAN, EDITH A.
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-36757
GUYENNE, T. D.
Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354
GWYNNE, PETER
Space Station business p 169 A87-47726
GYURDZHIAN, A. A.
Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732

H

HAAG, THOMAS W.
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 83 A87-50187
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 86 N87-23621
HABLANI, HARI B.
Modal analyses of dynamics of a deformable multibody spacecraft - The Space Station: A continuum approach
[AIAA PAPER 87-0925] p 17 A87-33727
HAFTKA, RAPHAEL T.
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33610
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46793
An analytical and experimental investigation of output feedback vs. linear quadratic regulator
[AIAA PAPER 87-2390] p 61 A87-50474
HAGEDORN, P.
Active vibration damping of flexible structures using the travelling wave approach p 71 N87-2[illegible]90
HAGLUND, R. F.
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-26191
HAGLUND, RICHARD F., JR.
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181
HAHN, E.
Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2588] p 62 A87-50558
Adaptive momentum management for large space structures
[NASA-CR-179085] p 67 N87-22758
HAHN, H.
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
HAILE, W. B.
Vibration isolation for line of sight performance improvement p 67 N87-22742
HAINES, RICHARD F.
Design and development of a Space Station proximity operations research and development mockup
[SAE PAPER 861785] p 133 A87-32634
HALE, ARTHUR L.
Large spacecraft pointing and shape control
p 69 N87-24488
HALL, J. B.
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32686
Evaluation of Space Station thermal control techniques
[SAE PAPER 860998] p 42 A87-36775
HALL, JOHN B., JR.
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration
[SAE PAPER 860916] p 47 A87-36708
Supercritical water oxidation - Concept analysis for evolutionary Space Station application
[SAE PAPER 860993] p 51 A87-36770
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53979
HALLAUER, WILLIAM L., JR.
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
An experimental study of transient waves in a plane grid structure
[AIAA PAPER 87-0943] p 18 A87-33741
An analytical and experimental investigation of output feedback vs. linear quadratic regulator
[AIAA PAPER 87-2390] p 61 A87-50474
HALLINAN, G. J.
Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 78 N87-23695
Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696
HALPERN, BRET
Product energy distributions and energy partitioning in O atom reactions on surfaces p 109 N87-26180
HALSEMA, P. B.
Multiple beam phased array for Space Station Control Zone Communications p 85 A87-45519
HAM, FREDRIC M.
Active damping control design for the COFS Mast Flight System
[AIAA PAPER 87-2321] p 23 A87-50442
HAMAGUCHI, TATSUYA
Solar concentrator system for experiments in the Space Station p 146 A87-32535
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548
HAMEL, W. R.
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004816] p 101 N87-22231
Traction-drive telerobot for space manipulation
[DE87-005328] p 102 N87-22233
Telerobotic technology for nuclear and space applications
[NASA-CR-180923] p 102 N87-22242
HAMMOND, RONALD A.
Space Station autonomy - What are the challenges? How can they be met? p 101 A87-53058
HANAGUD, S.
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0959] p 18 A87-33751
An AI-based model-adaptive approach to flexible structure control
[AIAA PAPER 87-2457] p 61 A87-50503
HANKS, BRANTLEY R.
Future trends in spacecraft design and qualification
p 2 N87-20358
Status of the Mast experiment p 30 N87-22703
HANSEN, IRVING G.
Space Station 20-kHz power management and distribution system p 75 A87-36913
20 kHz Space Station power system
p 76 A87-40379
EMC and power quality standards for 20-kHz power distribution
[NASA-TM-89925] p 78 N87-22004
HANSMAN, R. JOHN
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement
p 94 N87-21147
HANSON, JOHN M.
Combining space-based propulsive maneuvers and aerodynamic maneuvers to achieve optimal orbital transfer
[AIAA PAPER 87-2587] p 93 A87-49817
HARADA, H.
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-38626
HARADA, MINORU
Japanese experiment module data management and communication system p 147 A87-32542
HARADA, Y.
Space stable thermal control coatings
[AD-A182788] p 110 N87-28584
HARCROW, H. W.
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371
HARDING, R. R.
The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178182] p 9 N87-21895
HARDY, A.
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-49026
HARRIES, J. E.
Report of the atmosphere panel p 161 N87-20633
HARRIS, CINDY J.
Special considerations in outfitting a space station module for scientific use
[SAE PAPER 860956] p 164 A87-36741
HARRIS, ELFREEDA
SOT: A rapid prototype using TAE windows
p 114 N87-23181
HARRIS, PHILIP R.
Innovations in space management - Macromanagement and the NASA heritage p 167 A87-34875
HARRISON, B. H.
Space Station - Opportunities for the life sciences
p 122 A87-34871
HART, SANDRA G.
Workshop on Workload and Training, and Examination of their Interactions: Executive summary
[NASA-TM-89458] p 171 N87-25760
HARTENSTEIN, R.
Fiber optic data systems p 117 N87-29152
SS focused technology: Gateways and NOS's
p 117 N87-29185
HARTLEY, CRAIG S.
Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 99 A87-31493
Planning for unanticipated satellite servicing teleoperations p 119 A87-33048
HARTLEY, JAMES G.
Evaluation of Space Station thermal control techniques
[SAE PAPER 860998] p 42 A87-36775
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181009] p 45 N87-26072
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-26838
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702
HARTZELL, EARL J.
Workshop on Workload and Training, and Examination of their Interactions: Executive summary
[NASA-TM-89458] p 171 N87-25760
HARVEY, J. M.
GaAs concentrator solar arrays p 82 N87-26877
HARVEY, M. S.
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38615
HASEGAWA, T.
Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-36843
HASHIMOTO, KAZUHIKO
Communication missions for geostationary platforms
p 84 A87-34797
HASSELMAN, T. K.
MOVER II - A computer program for verifying reduced-order models of large dynamic systems
[SAE PAPER 861790] p 5 A87-32639
A computer program for model verification of dynamic systems p 31 N87-22710
HASTINGS, DANIEL E.
The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42586
HATAYAMA, SHIGEKI
Gas and water recycling system for IOC vivarium experiments p 46 A87-32457
HATFIELD, J. J.
Electronic control/display interface technology
p 98 N87-29181
HATHAWAY, ROY
Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54169
HATTIS, PHILIP D.
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37298
HAVILAND, J. K.
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 60 A87-50415
Digital control system for space structure dampers
[NASA-CR-181252] p 72 N87-27704
HAWKES, THADDEUS A.
An advanced geostationary communications platform
p 125 A87-43169

HAY, STUART S.
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 93 A87-50197
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[NASA-TM-100113] p 96 N87-23621
HAYASHI, SHIGERU
Gas and water recycling system for IOC vivarium experiments p 46 A87-32457
HAYASHI, TOMONAO
Thermal verification method for large sized spacecraft
p 144 A87-32398
HAYASHIGUCHI, SATOSHI
Thermal verification method for large sized spacecraft
p 144 A87-32398
HAYWOOD, D.
GaAs concentrator solar arrays p 82 N87-26677
HEALEY, MIKE
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443
HEATH, ELLEN F.
Development of a standard connector for orbital replacement units for serviceable spacecraft
p 40 N87-29864
HEBRARD, PAUL
PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44588
HECKERT, B. J.
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-29132
HECKS, K.
Mechanical design of the Eurostar platform
p 149 A87-34874
HEDGEPETH, JOHN M.
Structural concepts for large solar concentrators
[NASA-CR-4075] p 85 N87-21994
HEESCHEN, G.
Aerospatiale solar arrays, in orbit performance
p 159 N87-26688
HEFNER, L.
Data management system architecture options for space stations
[SES/DNP/TR/002/85] p 115 N87-26595
HEFNER, R. D.
Robust controller design using frequency domain constraints p 11 A87-32229
HEGGEN, PHILIP B.
Design considerations for long-lived glass mirrors for space p 123 A87-36631
HEHNEN, R.
Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-48138
HEIMBOLD, G.
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2381-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707
Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2381-VOL-4] p 73 N87-27709
HEIZER, B. L.
Environmental avoidance concepts for steerable Space Station radiators
[SAE PAPER 881631] p 41 A87-32895
HEJTMANCIK, KELLY E.
Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26703
HELD, DAN
The Earth Observing System (EOS) synthetic aperture radar (SAR) p 129 A87-44187
HELLER, JACK
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-88788] p 79 N87-25839
HELMREICH, ROBERT L.
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180342] p 53 N87-27406
HELPPIE, MARTHA
Soviet space stations as analogs, second edition
[NASA-CR-180880] p 157 N87-21889
HENDRICKSON, ERIC
An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 881822] p 74 A87-32579
HENDRICKS, HERBERT D.
Fiber optics wavelength division multiplexing(components) p 117 N87-29151
Fiber optics common transceiver module
p 117 N87-29160
HENDRIX, S. P.
EDC development and testing for the Space Station program
[SAE PAPER 860919] p 119 A87-38710
HENNIGES, BEN L.
Active damping control design for the COFS Mast Flight System
[AIAA PAPER 87-2321] p 23 A87-50442
HEPPNER, DENNIS B.
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 861007] p 52 A87-38779
HERNDON, J. N.
Traction-drive telerobot for space manipulation
[DE87-005326] p 102 N87-22233
Telerobotic technology for nuclear and space applications
[NASA-CR-180823] p 102 N87-22242
HERRING, MARK
Conceptual design of the High-Resolution Imaging Spectrometer (HIRIS) for EOS p 129 A87-44185
HERSTROM, CATHERINE L.
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0899] p 15 A87-33633
HIGUCHI, K.
Status of Japanese Experiment Module design
p 145 A87-32531
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570
Japanese customer needs for Space Station
[AIAA PAPER 87-2193] p 153 A87-48580
HIGUCHI, KEN
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0886] p 14 A87-33632
HIGUCHI, KIYOSHI
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
HILBRANDT, E.
Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-64/86] p 35 N87-24516
HILCHEY, JOHN D.
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-38740
HILL, DAVID G. C.
Development status of a two-phase thermal management system for large spacecraft
[SAE PAPER 881629] p 41 A87-32882
HILL, OLIVER
Aero-Assisted Orbital Transfer Vehicle (AOTV)
p 3 N87-20882
HILL, S. G.
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings
p 167 A87-38576
HINES, B. D.
Concepts for space maintenance of OTV engines
p 135 A87-41161
Concepts for space maintenance of OTV engines
p 135 A87-48000
Concepts for space maintenance of OTV engines
p 137 N87-26087
HINRICHSEN, R. L.
The effects of structural perturbations on decoupled control p 35 N87-25359
HIRAO, K.
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
HIRNICK, L. V.
Frequency dispersion in the admittance of the polycrystalline CuInSe/CdS solar cell p 5 A87-29133
HOCHSTEIN, J. I.
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 93 A87-52247
HOCHSTEIN, JOHN I.
Numerical modelling of cryogenic propellant behavior in low-G [illegible] N87-21148
HODGE, JOHN D.
The Space Station overview [illegible] A87-41571
HOFFBAUER, M. A.
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies
p 105 A87-32080
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-29168
HOFFBAUER, M. H.
Mass spectrometers and atomic oxygen
p 141 N87-29176
HOFFMAN, DAVID J.
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 92 A87-52252
Resistojet plume and induced environment analysis
[NASA-TM-88957] p 96 N87-24536
HOFFMAN, R. W.
Oxygen interaction with space-power materials
[NASA-CR-181389] p 132 N87-29033
HOFFMANN, HANS E. W.
The industrial use of Spacelab p 168 A87-42286
HOGGATT, J. T.
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings
p 167 A87-38576
HOHLFELD, ROBERT
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-29081
HOLCOMB, LEE
Overview of the NASA automation and robotics research program p 100 A87-32867
HOLMES, J.
GPS applications to the Space Station
p 136 A87-45525
HOLZACH, H.
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707
HONVAULT, CLAUDE
ESA's future integrated space data system
[AIAA PAPER 87-2180] p 153 A87-48579
HOOVER, DANIEL J.
Space Station based options for orbiter docking/berthing p 138 N87-29877
HOPKINS, M.
Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2596] p 62 A87-50558
HOPKINS, MIRIAM
Space station momentum management
p 61 N87-20868
HOPMANN, HELMUT
Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-162] p 90 A87-42880
HORIO, M.
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48602
HORN, F. L.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 89 N87-29405
HORNER, GARNETT C.
Microprocessor controlled proof-mass actuator
p 65 N87-22706
HORNUNG, E.
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 39 N87-29075
HORTA, LUCAS G.
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47909
HOSFORD, GREGORY S.
Hydrogen-oxygen thruster with no products of combustion in exhaust plume
[AIAA PAPER 87-1775] p 91 A87-45198
HOSOSAI, HIDEHO
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel
p 55 A87-32448
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50333
HOTES, DEBORAH
An evaluation of candidate oxidation resistant materials for space applications in LEO
[NASA-TM-100122] p 107 N87-25480
An evaluation of candidate oxidation resistant materials p 110 N87-26203
HOUSTON, S. J.
On-orbit assembly and repair p 135 A87-40379
HOWARD, J.
GaAs concentrator solar arrays p 82 N87-26677

240

HOWELL, DAVID
Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48587
HOWLAND, T. P.
Complex system monitoring and fault diagnosis using communicating expert systems p 113 A87-42083
HOYNIAK, D.
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 166 A87-25396
HUANG, JEN-KUANG
Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2367] p 24 A87-50471
Projection filters for modal parameter estimate for flexible structures
[NASA-CR-180303] p 28 N87-26583
HUBBARD, JAMES E., JR.
Active vibration control of a simply supported beam using a spatially distributed actuator p 23 A87-50232
HUENERS, E.
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 36 N87-26075
HUENERS, H.
Modal-survey testing for system identification and dynamic qualification of spacecraft structures
p 27 N87-20365
HUETER, UWE
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1498] p 90 A87-43027
HUGHES, P. C.
Dynamics of gyroelastic spacecraft p 58 A87-47811
HUGHES, PETER C.
Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32120
HUGHES, ROBERT O.
Linear quadratic control system design for Space Station pointed payloads
[AIAA PAPER 87-2530] p 161 A87-50535
Impact of space station appendage vibrations on the pointing performance of gimballed payloads
p 32 N87-22733
HUMPHRIES, W. R.
Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 48 A87-36730
HUMPHRIES, WILLIAM R.
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-36729
HUNT, DAVID L.
A modern approach for modal testing using multiple input sine excitation
[AIAA PAPER 87-0884] p 19 A87-33754
HUNT, J. J.
Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354
HUNT, J. W.
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236
HUNTON, D. E.
Mass spectrometers and atomic oxygen
p 141 N87-26176
HURLEY, K.
The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-38443
HUSS, R. L.
Commercial US transfer vehicle overview
[SAE PAPER 861784] p 1 A87-32625
HUTH, G.
GPS applications to the Space Station
p 136 A87-45525
HUTTENBACH, ROBIN C.
An evolutionary approach to the development of a CELSS based air revitalisation system
[SAE PAPER 860969] p 49 A87-36750
HUYER, STEPHEN A.
An equivalent continuum analysis procedure for Space Station lattice structures
[AIAA PAPER 87-0724] p 13 A87-33564
HWANGBO, HAN
High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-32377
HYLAND, D. C.
The Mast Flight System dynamic characteristics and actuator/sensor selection and location
[AAS PAPER 86-003] p 13 A87-32726
Reduced-order compensation - LQG reduction versus optimal projection
[AIAA PAPER 87-2388] p 61 A87-50472
Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 5 N87-22741
HYMAN, J.
Automatic charge control system for geosynchronous satellites p 67 N87-26065

I

IAKSHIN, A. B.
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment
p 148 A87-34207
IATSYNIN, NIKOLAI ALEKSANDROVICH
Structure and design of spacecraft
p 155 A87-51670
IBRAHIM, A. M.
Transient dynamics of orbiting flexible structural members p 54 A87-32338
A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574
A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 35 N87-25357
IIDA, TAKASHI
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
Communication missions for geostationary platforms
p 84 A87-34787
Japan's space development programs for communications - An overview p 152 A87-43158
IIZUKA, I.
Japanese customer needs for Space Station
[AIAA PAPER 87-2193] p 153 A87-48580
IIZUKA, ISAO
Japanese experiment module data management and communication system p 147 A87-32542
IJICHI, K.
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-36829
IJICHI, KOICHI
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32386
IKEGAMI, R.
Experimental characterization of deployable trusses and joints p 33 N87-22748
IKEGAMI, ROY
The design and analysis of passive damping for aerospace systems
[AIAA PAPER 87-0881] p 58 A87-36844
IKEUCHI, M.
Japanese data relay satellite system
[AIAA PAPER 87-2189] p 154 A87-48585
IMAI, RYOICHI
Structural design and component tests of large geostationary satellite bus p 144 A87-32326
IMAI, RYOUICHI
Development of fluid loop system for spacecraft
p 144 A87-32370
INDERBITZEN, REBECCA S.
Energy expenditure during simulated EVA workloads
[SAE PAPER 860921] p 183 A87-36713
INMAN, D. J.
Vibration suppression using a constrained rate-feedback Threshold control strategy
[AIAA PAPER 87-0741] p 6 A87-33665
Response bounds for linear underdamped systems
[ASME PAPER 87-APM-34] p 59 A87-42505
INMAN, DANIEL J.
Square root state estimator for large space structures
[AIAA PAPER 87-2389] p 24 A87-50473
INOUE, MASAO
Precise pointing control of flexible spacecraft
p 55 A87-32448
Development of a small-sized space manipulator
p 101 A87-51879
INOUE, YASUTOSHI
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540
IRBE, ROBERT
Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 50 A87-36762
IRBY, THOMAS B.
National space transportation studies
[SAE PAPER 861681] p 180 A87-32588
ISHIJIMA, SHINTARO
The mission function control for deployment and retrieval of subsatellite
[AIAA PAPER 87-2326] p 128 A87-50447
ISHIKAWA, M. Y.
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-008467] p 171 N87-22667
ISHIKAWA, TAKASHI
Tailored laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794
ISHLINSKII, A. IU.
The Gagarin scientific lectures in astronautics and aviation, 1985 p 152 A87-42923
The Gagarin Scientific Lectures on Astronautics and Aviation, 1986 p 169 A87-51889
ISOGAI, MASAHIRO
Vibration control for a linked system of flexible structures p 55 A87-32444
ITANAMI, TAKAO
On-board K- and S-band multi-beam antennas
p 86 A87-46281
ITO, TORU
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLPF method
p 144 A87-32324
IVEY, E. W.
Space station structures and dynamics test program
p 33 N87-22751
IVEY, EDWARD W.
Space station structures and dynamics test program
[NASA-TP-2710] p 29 N87-20588
IWASAKI, KAZUO
Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0742] p 148 A87-33667
IWATA, T.
Study of actuator for large space manipulator arm
p 12 A87-32545
A master-slave manipulator system for space use
p 147 A87-32546
IWATA, TAKANORI
System and operation analyses of OTV Network - A new space transportation concept p 145 A87-32475
IWATA, TOSHIAKI
Development of harmonic drive actuator for space manipulator p 149 A87-35078
Development of a small-sized space manipulator
p 101 A87-51879

J

JABBARI, FARYAR
Adaptive identification of flexible structures by lattice filters
[AIAA PAPER 87-2458] p 24 A87-50504
JACOT, A. D.
High speed simulation of flexible multibody dynamics
p 33 N87-22739
JAFFE, L.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145
JAFFE, LEONARD
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89298] p 79 N87-25838
JAFFE, R. L.
Potential surfaces for O atom-polymer reactions
p 139 N87-26201
JAFFE, RICHARD L.
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 139 N87-26182
JAGOW, BRUCE
Space Station EVA systems trade-off model
[SAE PAPER 860986] p 134 A87-36767
JAHN, ANDREAS
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 75 N87-24532
JAMAR, PAMELA
Head-ported display analysis for Space Station applications p 111 A87-31483
JANIK, DANIEL S.
Quality requirements for reclaimed/recycled water
[NASA-TM-58278] p 53 N87-27382
JANSSEN, D. R.
Summary of recent SAR instrument studies
p 158 N87-27865
JEANES, DENNIS P.
A multiple attribute decision analysis of manned airlock systems
[AD-A178241] p 137 N87-23892
JEBENS, HAROLD J.
Space colonization - T minus 20 (years) and holding
p 166 A87-32336
JENKINS, JAMES C.
National space transportation studies
[SAE PAPER 861681] p 180 A87-32588

JENKINS, LYLE M.
System architecture for the telerobotic work system [AAS PAPER 86-044] p 99 A87-32746
Telerobotic work system: Concept development and evolution p 104 N87-29886
JENSEN, G. A.
Joint technology for graphite epoxy space structures p 20 A87-38653
JENSEN, J. KERMIT
Mobile remote manipulator vehicle system [NASA-CASE-LAR-13393-1] p 103 N87-29118
JENSEN, ROBERT L.
Space Station end effector strategy study [NASA-TM-100486] p 103 N87-29583
JETLEY, R. L.
Space station experiment definition: Long-term cryogenic fluid storage [NASA-CR-4072] p 97 N87-24641
JEWELL, R. E.
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22729
JHA, V. K.
Optimization of aerospace structures subjected to random vibration and fatigue constraints p 29 N87-20586
JI, HYUN-CHUL
Temperature fields due to jet induced mixing in a typical OTV tank [AIAA PAPER 87-2017] p 83 A87-52247
JOHANSSON, O.
Radiation heat transfer calculations for space structures [AIAA PAPER 87-1522] p 44 A87-44830
JOHANNSEN, BERND
Preliminary analysis of a prototype space solar power system [ILR-MITT-180] p 79 N87-24532
JOHNSON, C. L.
The Vanderbilt University neutral O-beam facility p 105 A87-32059
JOHNSON, CATHERINE C.
Life Science Research Facility materials management requirements and concepts [SAE PAPER 860974] p 124 A87-26756
JOHNSON, D. L.
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations [NASA-CP-2460] p 64 N87-20886
JOHNSON, DERRICK W.
The design and analysis of passive damping for aerospace systems [AIAA PAPER 87-0891] p 58 A87-33644
JOHNSON, E. H.
ASTROS - A multidisciplinary automated structural design tool [AIAA PAPER 87-0713] p 6 A87-33657
JOHNSON, GARY
Habitation module for the Space Station [SAE PAPER 860926] p 163 A87-26718
JOHNSON, J. C.
International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings p 167 A87-26576
JOHNSON, KEVIN D.
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29593
JOHNSON, KURT P.
Perspectives on materials processing in space [AAS PAPER 86-100] p 170 A87-53083
JOHNSON, MARJORY J.
Proof that timing requirements of the FDDI token ring protocol are satisfied p 112 A87-42921
Network reliability p 117 N87-29157
JOHNSON, RICHARD D.
Space colonization - T minus 20 (years) and holding p 166 A87-32299
JOHNSON, TIMOTHY L.
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301
JONES, A. B.
Modal testing of the Olympus development model wound solar array p 27 N87-20366
JONES, BARBARA L.
Alternative power generation concepts for space p 81 N87-20661
JONES, D. I.
A microgravity isolation mount p 161 N87-20661
JONES, G. R.
Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle [AIAA PAPER 87-1535] p 160 A87-43201
JONES, L.
Space station propulsion test bed: A complete system p 98 N87-26131
JONES, MICHAEL R.
Modeling of environmentally induced transients within satellites [AIAA PAPER 85-0387] p 7 A87-41611
JONES, OGDEN S.
Mixing-induced ullage condensation and fluid destratification [AIAA PAPER 87-2018] p 92 A87-45257
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149
JONES, P. ALAN
Space Station alpha joint bearing p 83 N87-26862
JONES, R. E.
High speed simulation of multi-flexible-body systems with large rotations [AIAA PAPER 87-0930] p 57 A87-33730
High speed simulation of flexible multibody dynamics p 33 N87-22738
JONES, ROBERT E.
Space station propulsion system technology [NASA-TM-100108] p 97 N87-25422
Water-propellant resistojets for man-tended platforms [NASA-TM-100110] p 98 N87-26135
JONES, W. E.
Hubble Space Telescope satellite servicing [SAE PAPER 861795] p 133 A87-32844
JORDAN, PAUL R.
A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521
JOSEPH, K. T.
A basis change strategy for the reduced gradient method and the optimum design of large structures p 23 A87-48341
JOSHI, S. M.
Robust controller synthesis for a large flexible space antenna p 64 A87-32235
JUANG, J.-N.
Vibration suppression using a constrained rate-feedback Threshold control strategy [AIAA PAPER 87-0741] p 6 A87-33666
JUANG, JER-NAN
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47909
Robust eigensystem assignment for flexible structures [AIAA PAPER 87-2252] p 23 A87-50416
Single-mode projection filters for identification and state estimation of flexible structures [AIAA PAPER 87-2307] p 24 A87-50471
Slewing control experiment for a flexible panel p 78 N87-22740
Research in slewing and tracking control p 70 N87-24512
JUDAY, RICHARD D.
Optical correlator use at Johnson Space Center p 59 A87-42656
JUDD, D. S.
Materials for space applications p 109 A87-44741
JUENGST, C. D.
High speed simulation of flexible multibody dynamics p 33 N87-22738
JUHASZ, ALBERT
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems [NASA-TM-89886] p 76 N87-22174
JUHASZ, ALBERT J.
Alternative power generation concepts for space p 81 N87-26661
JUILLET, J. J.
Aerospatiale solar arrays, in orbit performance p 159 N87-26869
JUNG, G.
A maintenance work station for Space Station [SAE PAPER 860953] p 167 A87-26723
JUNKINS, J. L.
A quasi-analytical method for non-iterative computation of nonlinear controls p 66 N87-22731
JUNKINS, JOHN L.
Robustness optimization of structural and controller parameters [AIAA PAPER 87-0791] p 14 A87-33681
An identification method for flexible structures [AIAA PAPER 87-0745] p 16 A87-33668
Robust eigensystem assignment for flexible structures [AIAA PAPER 87-2252] p 23 A87-50416
JUSTAFERRO, A.
On-orbit assembly and repair p 135 A87-40376

K

KAASE, H.
Absolute indoor calibration of large area solar cells p 159 N87-29015
KAJII, M.
Japanese data relay satellite system [AIAA PAPER 87-2198] p 154 A87-48385
KALYANASUNDARAM, S.
Dynamic response of a viscoelastic Timoshenko beam [AIAA PAPER 87-0890] p 16 A87-33708
KAMENETSKAIA, E. P.
Legal problems concerning manned space flight p 151 A87-40326
KAMMER, DANIEL C.
Comparison of the Craig-Bampton and residual flexibility methods of substructure representation p 19 A87-34510
KANDA, SHUJI
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
KANG, CHOONG S.
Dynamic analysis of the flexible boom in the N-ROSS satellite [AD-A181468] p 72 N87-26686
KARDOMATEAS, G. A.
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads [AIAA PAPER 87-0877] p 105 A87-33639
KARNICK, DREW A.
Moving-bank multiple model adaptive estimation applied to flexible spacestructure control [AD-A178870] p 68 N87-22761
KASAI, RITAROH
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32389
KASHIWASE, TOSHIO
Precise pointing control of flexible spacecraft p 55 A87-32446
KATO, T.
Mission scheduling expert system and its space station applications [AIAA PAPER 87-2221] p 7 A87-48802
KATZ, I.
Theory of plasma contactors for electrodynamic tethered satellite systems p 85 A87-41609
Ram ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51713
Documentation for the SHADO particle wake routine [AD-A181531] p 131 N87-26687
KATZBERG, STEPHEN J.
Space Station end effector strategy study [NASA-TM-100486] p 103 N87-29583
KAUFFMAN, DAVID
An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-25666
KAUFFMAN, S. R.
The multi-disciplinary design study. A life cycle cost algorithm [NASA-CR-178182] p 9 N87-21886
KAWADA, B.
Study of actuator for large space manipulator arm p 12 A87-32545
KAWAGUCHI, SHINTARO
A consideration to vibration control for a large space structures p 54 A87-32441
KAWAKAMI, KUNIHIKO
Solar concentrator system for experiments in the Space Station p 149 A87-32535
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32546
KAWASAKI, MASAHIRO
Space Station program in a long-range space development scenario of Japan p 145 A87-32530
KAWASHIMA, N.
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
KEAFER, LLOYD S.
Large space antennas: A systems analysis case history [NASA-TM-89072] p 28 N87-20362
KEATES, T. F.
Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20368
KECKLER, CLAUDE R.
Control of flexible structures and the research community p 68 N87-22732
KEDROV, B. M.
K.E. Tsiolkovskii and problems in the development of science and technology p 151 A87-40342

KEFAUVER, NEILL
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21967
KEINHOLZ, D. A.
Experimental characterization of deployable trusses and joints p 33 N87-22749
KELLY, BRIAN K.
A systems analysis of emergency escape and recovery systems for the US space station
[AD-A179233] p 3 N87-23680
KEMPSTER, LINDA
Mass storage systems for data transport in the early space station era 1992-1996
[NASA-TM-87826] p 115 N87-27443
KENNEDY, JOHN J.
The preloadable vector sensitive latch for orbital docking/berthing p 162 N87-29870
KERRINNES, OLAF
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532
KERSTEIN, L.
The evolution of a serviceable EURECA
[MBB-UR-E-923/86] p 121 N87-26841
KETCHUM, W. J.
Orbital transfer vehicle concept definition and system analysis study. Volume 1A: Executive summary. Phase 2
[NASA-CR-179055] p 161 N87-21018
KHOT, N. S.
Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737
KHOURY, JIM M.
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 861007] p 52 A87-38779
KIA, T.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145
KIBE, SEISHIRO
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548
KIDA, TAKASHI
Local control for large space structures
p 54 A87-32440
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540
KIDGER, NEVILLE
Mir in action p 150 A87-37971
KILLEBREW, TIMOTHY D.
Military man in space: A history of Air Force efforts to find a manned space mission
[AD-A178873] p 171 N87-25815
KIM, BI-KUN
Modeling of fluid transfer in orbit
[AIAA PAPER 87-1763] p 90 A87-45180
KIM, ZEEN C.
Interdisciplinary analysis procedures in the modeling and control of large space-based structures
p 22 A87-42879
KIM, ZEEN CHUL
An investigation of methodology for the control and failure identification of flexible structures
p 39 N87-26821
KING, C. B.
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-179208] p 120 N87-20340
KIRKHART, J. L.
Evaluation of carbon-carbon for space engine nozzle
p 98 N87-26118
KIRKPATRICK, MARC E.
Spacecraft environment interaction investigation
[AD-A179183] p 140 N87-23678
KISSEL, GLEN J.
Localization in disordered periodic structures
[AIAA PAPER 87-0819] p 18 A87-33757
KIYAMURA, KATSUHIDE
Development of graphite epoxy space structure
p 106 A87-32342
KITTEL, PETER
Transferring superfluid helium in space
p 88 A87-34712
Helium technology issues p 94 N87-21145
KLEINAU, W.
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573
KNOX, J.
A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications
[NASA-CR-177447] p 130 N87-25767
KOBAYASHI, TAKEHIKO
Thermal deformation and electrical degradation of antenna reflector with truss backstructure
p 12 A87-32405
KOCH, JUERGEN W.
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits
p 159 N87-26968
KOELLE, D. E.
The single-stage reusable ballistic launcher concept for economic cargo transportation p 135 A87-41573
KOELLE, HEINZ-HERMANN
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532
KOLKAILAH, FAYSAL A.
Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 136 N87-20306
KOLSCH, I.
Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-64/85] p 35 N87-24516
KOMATSU, TAKAHIRO
Development of fluid loop system for spacecraft
p 144 A87-32370
KORI, MORIS
Product energy distributions and energy partitioning in O atom reactions on surfaces p 108 N87-26180
KOSEKI, YASUO
Water recycling system using thermopervaporation method p 46 A87-32458
KOSMO, JOSEPH J.
Space suit extravehicular hazards protection development
[NASA-TM-89066] p 53 N87-27407
KOSMODEM'IANSKII, A. A.
K.E. Tsiolkovskii and problems in the development of science and technology p 151 A87-40342
KOVACH, LICIA S.
Environmental Control Life Support for the Space Station
[SAE PAPER 860944] p 48 A87-38731
KOWALEK, J.
A study of fluid transfer management in space
[FTMS-RPT-008] p 87 N87-26058
KOZLOV, S. V.
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-48121
KRAIMAN, HOWARD
Communication and Data Management Systems for an orbiting platform p 112 A87-40359
KRALL, A. M.
Modeling, stabilization and control of serially connected beams p 21 A87-41052
KRECH, ROBERT H.
A high flux pulsed source of energetic atomic oxygen
p 139 A87-39823
Pulsed source of energetic atomic oxygen
p 108 N87-26189
KROLICZEK, E. J.
Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32683
KRUEGER, MICHAEL
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532
KRUMWEIDE, GARY C.
Measuring thermal expansion in large composite structures p 20 A87-39812
KU, J.
Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32683
KUBAN, D. P.
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004816] p 101 N87-22231
Traction-drive telerobot for space manipulation
[DE87-005338] p 102 N87-22233
Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-29867
KUBOTA, YUJI
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SUPF method
p 144 A87-32334
KUCZERA, H.
Micrometeorite exposure of solar arrays
p 82 N87-29882
KUHL, R.
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6
p 147 A87-32814
KULCHYSKI, R. B.
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370
KUMAGIRI, YASUO
Evaluation testing of a mechanical actuator component operating in a simulated space environment
p 160 A87-32549
KUMAR, K.
Analytical solutions for static elastic deformations of wire ropes
[AIAA PAPER 87-0720] p 6 A87-33581
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180686] p 28 N87-20569
A new approach for vibration control in large space structures p 33 N87-22743
KUMINECZ, J.
Review of Low Earth Orbital (LEO) flight experiments
p 131 N87-26174
KUNII, Y.
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-39628
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-39629
KUO, C. P.
Validation of large space structures by ground tests
p 11 A87-32338
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0748] p 16 A87-33670
Verification of flexible structures by ground test
p 31 N87-22713
KUO, C-P.
Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-20581
KUO, SHAU-HERN
Optimal nodal transfer and aeroassisted transfer by aerocruise p 138 N87-26577
KURACHI, S.
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443
KURIKI, KYOICHI
Advanced technology experiment onboard space platform p 122 A87-32536
KURITA, Y.
Study of actuator for large space manipulator arm
p 12 A87-32545
KURITZ, STEVEN P.
Application of physical parameter identification to finite-element models p 34 N87-24505
KUROKAWA, HARUHISA
A study on singularity of single gimbal CMG systems
p 149 A87-35077
KUROKAWA, HIDEAKI
Water recycling system using thermopervaporation method p 46 A87-32458
KUSSMAUL, MICHAEL
An evaluation of candidate oxidation resistant materials p 110 N87-26203
KUTYNA, FRANK
Space motion sickness status report
[SAE PAPER 860923] p 163 A87-38714
KUWAO, FUMIHIRO
Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33667
The design and development of a two-dimensional adaptive truss structure p 40 N87-29880
KUZNETSOV, A.
The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-39443
KWATNY, H. G.
Practical issues in computation of optimal, distributed control of flexible structures
[AIAA PAPER 87-2481] p 25 A87-50607
Modeling and control of flexible structures
[AD-A177108] p 29 N87-21368
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179738] p 35 N87-24517

L

LABED, RICHARD
An evaluation of candidate oxidation resistant materials p 110 N87-26203

LABUS, THOMAS L.
Space station electrical power system
[NASA-TM-100140] p 80 N87-26144

LACOMBE, J. L.
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-26260

LACOVARA, ROBERT C.
Integration of communications and tracking data processing simulation for space station
p 115 N87-25890

LACY, DOVIE E.
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems
[NASA-TM-89886] p 78 N87-22174

LAFRAMBOISE, J. G.
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved
p 142 N87-26949

LAKE, MARK S.
Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89068] p 37 N87-26085

LALIBERTE, D.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

LALLMAN, FREDERICK J.
Dual keel space station control/structures interaction study p 67 N87-22737

LAMB, J. PARKER
U.S. National Congress of Applied Mechanics, 10th, University of Texas, Austin, June 16-20, 1986, Proceedings
[AD-A181962] p 1 A87-40051

LANE, BARTON G.
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23066

LANG, JEFFREY H.
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301

LANGE, TH.
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2361-VOL-1] p 73 N87-27707
Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2361-VOL-4] p 73 N87-27709

LANGEMANN, M.
An advanced wind scatterometer for the Columbus Polar Platform payload p 156 A87-53117

LANGER, W. D.
Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26200

LANGSTON, CHARAN J.
End-to-end communications for Space Station
p 85 A87-45522

LANTRIP, DAVID B.
ISOKIN - A quantitative model of the kinesthetic aspects of spatial habitability p 162 A87-33002

LANZ, MASSIMILIANO
Active structural controllers emulating structural elements by ICUs p 27 N87-20367

LANZEROTTI, LOUIS J.
A crisis in the NASA space and earth sciences programme p 112 A87-37998

LANZL, F.
Land panel report p 128 N87-20834

LARKINS, J. T.
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712

LARSEN, RON
Overview of the NASA automation and robotics research program p 100 A87-33867

LARSEN, RONALD L.
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89295] p 116 N87-29124
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89296] p 116 N87-29144

LARSON, C. R.
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721

LASKIN, ROBERT A.
The Softmounted Inertially Reacting Pointing System (SIRPNT)
[AAS PAPER 86-007] p 56 A87-32732
On the inadequacies of current multi-flexible body simulation codes
[AIAA PAPER 87-2248] p 7 A87-50412

LASKOWSKI, B. C.
Potential surfaces for O atom-polymer reactions
p 109 N87-26201

LATHAM, P. M.
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015

LAUBER, R. J.
Automated software production
[AIAA PAPER 87-2219] p 2 A87-48801

LAUFENBERG, ROBERT S.
Computer simulation of a rotational single-element flexible spacecraft boom
[AD-A181798] p 103 N87-26968

LAUX, U.
System aspects of Columbus thermal control
[SAE PAPER 860938] p 150 A87-38727

LAVENDER, K. E.
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015

LAVIGNA, THOMAS A.
Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860973] p 134 A87-38755

LAWSON, B. MIKE
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734

LAWSON, R.
System aspects of Columbus thermal control
[SAE PAPER 860938] p 150 A87-38727

LAWTON, TONY
The Soviet space shuttle programme
p 153 A87-47302

LAZARETH, O.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-28405

LEBEAU, ANDRE
The astronaut and the robot - Short- and long-term scenarios for space technology p 101 A87-53991

LEBEDEV, M. A.
Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870

LECHTE, H.
MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-26980

LECHTE, H. G.
Stopping differential charging of solar arrays
p 83 N87-26984

LECHTE, HORST G.
Electrostatic immunity of geostationary satellites
p 143 N87-26957

LEE, ALECK L.
External contamination environment of Space Station Customer Servicing Facility
[AIAA PAPER 87-1623] p 52 A87-43122

LEE, BYOUNG-SOO
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2464] p 93 A87-50509

LEE, C. Y.
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1540] p 44 A87-44843

LEE, S. W.
Dynamic finite element modeling of flexible structures
[AD-A177168] p 30 N87-22252

LEE, W. Y.
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31881

LEGER, L.
Selected materials issues associated with Space Station p 105 A87-32081
Review of Low Earth Orbital (LEO) flight experiments
p 131 N87-29174

LEGER, LUBERT
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-29168

LEGER, LUBERT J.
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements
p 108 N87-29175
Space Station lubrication considerations
p 104 N87-28879

LEGOSTAEV, V. P.
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801

LEINWEBER, DAVID
Expert systems in space p 111 A87-32075

LEISEIFER, H. P.
Columbus Life Support System and its technology development
[SAE PAPER 860966] p 150 A87-38748

LEKAN, JACK
An advanced geostationary communications platform
p 125 A87-43165

LEMAIGNEN, LOUIS
Physiological requirements and pressure control of a spaceplane
[SAE PAPER 860965] p 150 A87-38747

LEMKE, DIETRICH
The Space Station - Uses and users
p 151 A87-40513

LEMPRIERE, B. M.
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179187] p 4 N87-28583

LENOROVITZ, JEFFREY M.
Advances by the Soviet Union in space cooperation and commercial marketing made 1986 a landmark year
p 149 A87-34595

LERNER, ERIC J.
Robots on the Space Station p 100 A87-40844

LERNER, NARCINDA R.
Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-26197

LESOMA, S. K.
The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35799

LESOTA, S. K.
Shape control of the directional pattern in a microwave-beam power transmission channel
p 148 A87-34345

LESTER, M.
The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-26942

LETAW, JOHN R.
Radiation shielding requirements on long-duration space missions
[AD-A177512] p 140 N87-21991

LETCHWORTH, ROBERT
COFS 3 multibody dynamics and control technology
p 69 N87-24508

LEVADOU, FRANCOIS
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32346

LEVITAN, LEE
Head-ported display analysis for Space Station applications p 111 A87-31483

LEVY, D. R.
Mass property estimation for control of asymmetrical satellites p 83 A87-52988

LEVY, E. H.
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

LEVY, JOEL
Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860973] p 134 A87-38755

LEVY, L.
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit
p 158 N87-26953
MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-26980

LI, DECHANG
Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-40887

LI, FEIYUE
Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26038
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712

LIANDRIS, MARIA
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125

LIANG, RANTY H.
Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38825
Degradation studies of SMRM teflon
p 108 A87-38841
O-atom degradation mechanisms of materials
p 141 N87-29179

Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-26190

LICHTENBERG, BYRON K.
Human capabilities in space
[AAS PAPER 86-114] p 165 A87-53089

LIENING, FREDERICK A.
CELSS waste management systems evaluation
[SAE PAPER 860997] p 51 A87-38774

LIKINS, PETER W.
Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-40667

LILES, PAUL D.
On board Data Management p 112 A87-40381

LILLINGTON, DAVID R.
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424

LIM, KYONG B.
Robustness optimization of structural and controller parameters
[AIAA PAPER 87-0791] p 14 A87-33591
Robust eigensystem assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416

LIM, T. W.
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 60 A87-50415

LIN, C.
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860994] p 51 A87-38771

LIN, CAI
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures
[NASA-CR-180317] p 38 N87-27280

LINDLEY, THOMAS L.
On-board communications, including EVA
p 85 A87-40380

LINDSAY, K. L.
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531

LIU, FRANK C.
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752

LLEWELLYN, E. J.
Spacecraft ram glow and surface temperature
p 10 N87-26205

LODGE, D. W. S.
British activities in space p 143 A87-32280
Design of a polar platform with an earth observation payload p 122 A87-32538

LOESER, H.
Life support subsystem concepts for botanical experiments of long duration
[MBB-UR-E-907-86-PUB] p 154 A87-48667

LOESER, HELMUT R.
Botanical payloads for platforms and space stations
[MBB-UR-E-921/86] p 158 N87-25340

LOFLAND, WILLIAM W., JR.
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38794

LOFTUS, JOSEPH P.
Man's role in space exploration and exploitation
p 169 A87-48232

LOGSDON, JOHN M.
Reconstituting the US space programme
p 168 A87-41219
Priorities and policy analysis - A response to Alex Roland p 168 A87-41222

LOH, Y. C.
Antenna systems and RF coverage for the Space Station p 2 A87-45523

LONGHURST, F.
The Columbus system baseline and interfaces
p 158 A87-53823

LONGMAN, R. W.
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25355

LORENZINI, ENRICO C.
A three-mass tethered system for micro-g/variable-g applications p 125 A87-40859
Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-179149] p 130 N87-26083

LORIA, ALBERTO
The Columbus program p 157 N87-25031

LOSER, H. R.
Life Support Subsystem concepts for botanical experiments of long duration
[SAE PAPER 860967] p 48 A87-38740

LOTTA, JOSEPH G.
Comparison of satellite support structure aluminum versus graphite epoxy
[SAWE PAPER 1682] p 20 A87-38279

LOUVIERE, ALLEN J.
Water-propellant resistojets for man-tended platforms
[NASA-TM-100110] p 96 N87-26135

LOVELACE, U. M.
Large space antennas: A systems analysis case history
[NASA-TM-89072] p 26 N87-20352

LOVELL, ROBERT R.
The evolution of the geostationary platform concept
p 125 A87-43154

LOW, D. I. R.
The Canadian space program p 143 A87-32281

LUCAS, J. C.
One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715

LUDEWIG, H.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

LUDLOW, GERRY
Space station power semiconductor package
[NASA-CR-180829] p 81 N87-29825

LUEST, R.
Cooperation between Europe and the United States in space (The Fulbright 40th Anniversary Lecture)
p 170 A87-53824

LUEST, REIMAR
The European space programme p 150 A87-37982

LUKICH, M. S.
On a balanced passive damping and active vibration suppression of large space structures
[AIAA PAPER 87-0801] p 19 A87-34701

LUKICH, MICHAEL S.
Application of physical parameter identification to finite-element models p 34 N87-24505

LYNN, DAVID
Space Station opportunity for UK in earth sensing
p 152 A87-41678

LYON, JOHN
Data capture and processing
[AIAA PAPER 87-2203] p 113 A87-48588

LYRINTZIS, C. S.
Vibrations and structureborne noise in space station
[NASA-CR-181381] p 39 N87-29580

M

MA, PAUL T.
External contamination environment of Space Station Customer Servicing Facility
[AIAA PAPER 87-1622] p 52 A87-43122

MAAG, CARL R.
Design considerations for long-lived glass mirrors for space p 123 A87-38831

MACHIDA, K.
Study of actuator for large space manipulator arm
p 12 A87-32545
A master-slave manipulator system for space use
p 147 A87-32546

MACHIDA, KAZUO
Development of harmonic drive actuator for space manipulator p 148 A87-35076
Development of a small-sized space manipulator
p 101 A87-51879

MACKOW, G. E.
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31462

MACKOWSKI, MAURA J.
Safety on the Space Station p 162 A87-35589

MAEKAWA, SHOJI
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLFF method
p 144 A87-32334

MALLA, RAMESH-BABU
Dynamic and thermal effects in very large space structures p 25 N87-20347

MALLARY, WILLIAM E.
Space Station data management system architecture
p 111 A87-37283

MALLETTE, MICHAEL FREDERICK
Theory and application of linear servo dampers for large scale space structures p 72 N87-26870

MAMODE, A.
Low frequency vibration testing on satellites
p 27 N87-20384
The high performance solar array GSR3
p 81 N87-20872

MANSOURI, RAMI S.
On the performance analysis of a real-time distributed computer system p 111 A87-31518

MANUS, D.
On the dynamical stability of the space 'monorail'
p 149 A87-34047

MANNING, R. A.
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 56 A87-33573

MANOS, D. M.
Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26200

MANTEGAZZA, PAOLO
Active structural controllers emulating structural elements by ICUs p 27 N87-20387

MAO, C.
Organic Rankine cycle power conversion systems for space applications p 159 N87-29869

MARCHETTI, M.
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327

MARCUS, BETH A.
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720

MARELLI, L.
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20830
Data management panel report p 114 N87-20836

MARK, HANS MICHAEL
The Space Station: A personal journey
p 169 A87-48875

MARKER, W.
Space Station Information System integrated communications concept
[AIAA PAPER 87-2228] p 114 A87-48806
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2229] p 114 A87-48807

MARKS, G.
Modal testing of the Olympus development model stowed solar array p 27 N87-20388

MARTIN, A. R.
The use of electric propulsion on low earth orbit spacecraft
[AIAA PAPER 87-0989] p 88 A87-38003
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1031] p 89 A87-38015

MARTIN, JOHN
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443

MARTIN, R. A.
Advanced technology for extended endurance alkaline fuel cells p 75 A87-33767

MARTINEZ-SANCHEZ, MANUEL
Orbital modifications using forced tether-length variations p 124 A87-40858

MARTINEZ, A.
Concepts for space maintenance of OTV engines
p 135 A87-41161
Concepts for space maintenance of OTV engines
p 138 A87-48000
Concepts for space maintenance of OTV engines
p 137 N87-28097

Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-28280

MARTINEZ, PEDRO A.
Space station data management system - A common GSE test interface for systems testing and verification
p 112 A87-37284

MARTINOVIC, ZORAN N.
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 58 A87-33713
An analytical and experimental investigation of output feedback vs. linear quadratic regulator
[AIAA PAPER 87-2380] p 61 A87-50474

MARUIZUMI, HARUKI
Evaluation testing of a mechanical actuator component operating in a simulated space environment
p 160 A87-32549

MASRI, SAMI F.
Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180391] p 70 N87-24813

MASSEY, E.
Science Research Facilities - Versatility for Space Station
[SAE PAPER 860959] p 119 A87-38742

MASUKO, HARUNOBU
Observation of precipitation from space by the weather radar p 145 A87-32507

MATSUDA, HIROAKI
A thermally-pumped heat transport system
p 40 A87-32369

245

MATSUMOTO, K.
Japanese space information system overview
[AIAA PAPER 87-2191] p 153 A87-48579

MATSUMOTO, KOHTARO
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534

MATSUMURA, HIROYUKI
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456

MATSUO, HIROKI
International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volumes 1 & 2 p 166 A87-32276

MATSUZAKI, SATOSHI
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37653

MAZENKO, D. M.
Joint technology for graphite epoxy space structures
p 20 A87-38600

MAZZA, C.
Data management standards for space information systems
[AIAA PAPER 87-2205] p 113 A87-48580
ESA software engineering standards for future programmes
[AIAA PAPER 87-2207] p 154 A87-48582

MCCALEB, FRED
Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48587
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87826] p 115 N87-27443

MCCANNEY, J. M.
CP/MPS - Contained plasma magnetic propulsion system: An advanced propulsion concept
[AIAA PAPER 87-1042] p 89 A87-38016

MCCLURE, JOHN W.
A comparison of scheduling algorithms for autonomous management of the Space Station electric energy system
[AIAA PAPER 87-2487] p 77 A87-50511

MCCORMACK, PERCIVAL D.
Radiation dose prediction for Space Station
[SAE PAPER 860924] p 139 A87-38715

MCCORMICK, P. J.
Joint technology for graphite epoxy space structures
p 20 A87-38600

MCCOY, JAMES E.
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-210] p 89 A87-38569
Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572

MCCREIGHT, LOUIS R.
Computerized aerospace materials data; Proceedings of the Workshop on Computerized Property Materials and Design Data for the Aerospace Industry, El Segundo, CA, June 23-25, 1986 p 111 A87-35262

MCCUTCHEN, DON K.
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33737

MCDONALD, FRANK B.
Space research - At a crossroads
p 166 A87-32017

MCDONOUGH, THOMAS R.
Space the next twenty-five years p 168 A87-44375

MCELROY, JAMES F.
Space Station life support oxygen generation by SPE water electrolyzer systems
[SAE PAPER 860948] p 46 A87-38736

MCEVER, W. S.
High thermal capacity evaporator and condensers for Space Station thermal control p 41 A87-32377

MCGOWAN, DAVID M.
Experimental evaluation of small-scale erectable truss hardware
[NASA-TM-89059] p 37 N87-26085

MCGOWAN, PAUL E.
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739
Considerations in the design and development of a space station scale model p 9 N87-22711
COFS 3 multibody dynamics and control technology
p 69 N87-24506

MCGRATH, JAMES E.
Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182823] p 110 N87-27809

MCKAY, C. P.
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002

MCKNIGHT, DARREN SCOTT
Simulation of on-orbit satellite fragmentations
p 140 N87-24515

MCLAREN, M. D.
Robust multivariable control of large space structures using positivity p 59 A87-47810
Construction of positive real compensation for LSS control
[AIAA PAPER 87-2238] p 60 A87-50404

MCMILLAN, R. S.
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

MEACHAM, S. A.
The Oak Ridge National Laboratory's Robotics and Intelligent Systems Program
[DE87-004827] p 101 N87-20774

MEIROVITCH, L.
Equations of motion for maneuvering flexible spacecraft p 63 A87-52985
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734

MEIROVITCH, LEONARD
Sensitivity of distributed structures to model order in feedback control
[AIAA PAPER 87-0800] p 56 A87-33710
Some problems in the control of large space structures
[AD-A179889] p 70 N87-25350

MEIROVITCHT, L.
Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2250] p 60 A87-50414

MEISL, CLAUS
Density uncertainty effect on cost of space station reboost p 170 N87-20867

MEISSNER, D.
The Radarsat Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25506

MELL, R. J.
Space stable thermal control coatings
[AD-A182798] p 110 N87-28584

MENDE, S. B.
Spacecraft ram glow and surface temperature
p 10 N87-26205

MENEES, GENE P.
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2585] p 92 A87-49815

MENG, PHILLIP R.
Space station propulsion system technology
[NASA-TM-100108] p 97 N87-25422

MENNING, MIKE D.
Test results from the solar array flight experiment
p 83 N87-29010

MENZIES, ROBERT T.
Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986
[SPIE-644] p 125 A87-44176

MERCADAL, MATHIEU
Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180800] p 37 N87-26365

MERCANTI, ENRICO
LEO and GEO missions p 5 N87-29916

MERCIER, F.
Low frequency vibration testing on satellites
p 27 N87-20984

MERTESDORF, S. J.
The benefit of phase change thermal storage for spacecraft thermal management
[AIAA PAPER 87-1482] p 43 A87-43014

MESEROLE, JERE S.
Mixing-induced ullage condensation and fluid destratification
[AIAA PAPER 87-2018] p 92 A87-45357
Overview: Fluid acquisition and transfer
p 94 N87-21146
Mixing-induced fluid destratification and ullage condensation p 95 N87-21149

MESHISHNEK, M. J.
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182801] p 110 N87-29709

MESSIDORO, P.
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860939] p 150 A87-38729

METTLER, E.
Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24508

METZDORF, J.
Absolute indoor calibration of large area solar cells
p 159 N87-28015

METZINGER, R. W.
An integrated approach to spacecraft design for robotic servicing
[AIAA PAPER 87-1672] p 100 A87-41152

MEYA, ROBERT D.
1987 status report - United States Air Force electric propulsion research and development
[AIAA PAPER 87-1036] p 90 A87-41122

MEYER, D. PAUL
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-38762

MICHAL, R. J.
Fiber-optic monitors for space structures
p 11 A87-31505

MICHAUD, ROGER B.
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 860969] p 164 A87-38751
Concepts for the evolution of the Space Station Program
[SAE PAPER 860972] p 120 A87-38754

MIELE, A.
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31881

MIELKE, MICHAEL
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532

MIGRA, ROBERT P.
Microgravity fluid management requirements of advanced solar dynamic power systems
p 77 N87-21153

MIKULAS, MARTIN M., JR.
Design, construction, and utilization of a space station assembled from 5-meter erectable struts
p 34 N87-24501
Deployable geodesic truss structure
[NASA-CASE-LAR-13113-1] p 36 N87-25482
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 103 N87-29118

MILDICE, J. W.
Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88926] p 68 N87-23890

MILES, WILLIAM L.
Habitation module for the Space Station
[SAE PAPER 860929] p 163 A87-38718

MILLER, C. W.
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733

MILLER, CRAIG W.
Environmental Control Life Support for the Space Station
[SAE PAPER 860944] p 48 A87-38731

MILLER, D. P.
A two-dimensional numerical heat transfer model for a solar propulsion system p 74 A87-32308

MILLER, DANA
SOT: A rapid prototype using TAE windows
p 114 N87-23181

MILLER, DAVID F.
Gradient-based combined structural and control optimization p 21 A87-40888

MILLER, DAVID W.
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A179711] p 72 N87-29806

MILLER, L. J.
Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24508

MILLER, LADONNA J.
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 860969] p 164 A87-38751
Concepts for the evolution of the Space Station Program
[SAE PAPER 860972] p 120 A87-38754

MILLER, RICHARD K.
Structural concepts for large solar concentrators
[NASA-CR-4075] p 65 N87-21994

MILLER, NICOLAUS
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532

MINEMOTO, M.
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station
p 46 A87-32544

MINGORI, D. L.
Robust controller design using frequency domain constraints p 11 A87-32229
Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812

MINODA, YOSHIO
Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries p 107 A87-51772

MINOMO, MASAHIRO
On-board K- and S-band multi-beam antennas p 86 A87-46281

MIRTICH, MICHAEL
An evaluation of candidate oxidation resistant materials p 110 N87-26203

MIRTICH, MICHAEL J.
Oxidation protection coatings for polymers [NASA-CASE-LEW-14072-3] p 107 N87-23736

MITANI, KENJI
Water recycling for Space Station p 46 A87-32459

MITCHELL, J. R.
One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715

MITROKA, GEORGE D.
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities [AD-A180606] p 71 N87-25352

MITSUMA, HIDEHIDO
Structural design and component tests of large geostationary satellite bus p 144 A87-32335

MITSUMA, HIDEHIKO
Prediction of random vibrational responses of a large spacecraft in acoustic environment by BLPF method p 144 A87-32334

MIURA, K.
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340

MIURA, KORYO
Model study of simplex masts p 144 A87-32339
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341

MOCCIA, A.
The Tethered Satellite System as a new remote sensing platform p 124 A87-39183

MODI, V. J.
Transient dynamics of orbiting flexible structural members p 54 A87-32338
Deployment dynamics of space structures p 58 A87-40074
A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574
A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 35 N87-25357

MOE, KAREN L.
Standards for the user interface - Developing a user consensus [AIAA PAPER 87-2209] p 169 A87-48584

MOFFATT, MILES
The development of an EVA Universal Work Station [SAE PAPER 860952] p 164 A87-38739

MOHR, GEORGE C.
Robotic telepresence p 100 A87-46704

MOHRI, SATOSHI
Autonomous decentralized system concept for Space Station p 146 A87-32541

MONACO, C.
Data management system architecture opions for space stations [SES/DNP/TR/002/85] p 115 N87-28585

MONACO, S.
Sampled nonlinear control for large angle manouvers of flexible spacecraft p 71 N87-25358

MONSON, CONRAD B.
Physiological aspects of EVA [SAE PAPER 860891] p 164 A87-38768

MONTE, PAUL A.
Geostationary platforms - An international perspective p 121 A87-32288

MONTGOMERY, R. C.
On-line identification and attitude control for SCOLE [AIAA PAPER 87-2458] p 61 A87-50505

MONTGOMERY, RAYMOND C.
An overview of controls research on the NASA Langley Research Center grid p 68 N87-22720

MONTI, R.
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-38838

MONTI, RODOLFO
Tether system and controlled gravity [AAS PAPER 86-240] p 124 A87-38573

MOOK, D. T.
The effect of nonlinearities on flexible structures [AD-A181735] p 39 N87-27259

MOORE, C. J.
Space station structures and dynamics test program p 33 N87-22751

MOORE, CARLETON J.
Space station structures and dynamics test program [NASA-TP-2710] p 28 N87-20568

MOORE, E. A.
Common drive unit p 104 N87-29859

MOORMAN, GERARD J.
Real-time simulation for Space Station p 7 A87-37298

MORASKO, GWYNDOLYN
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs [SAE PAPER 860987] p 51 A87-38766

MOREL, A.
Ocean-ice panel report p 156 N87-20635

MORGAN, ERIC L.
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-40098

MORGANTI, F.
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327

MORI, KINJI
Autonomous decentralized system concept for Space Station p 146 A87-32541

MORI, TADAHISA
Japan's space development programs for communications - An overview p 152 A87-43156

MORIAI, T.
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU) [AIAA PAPER 87-1040] p 76 A87-39528
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU) [AIAA PAPER 87-1041] p 76 A87-39529

MORISHITA, Y.
Status of Japanese Experiment Module design p 145 A87-32531

MOROSOW, G.
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371

MOROZOV, A. I.
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32815
Critical length for stable elongated orbiting structures p 148 A87-32819

MORREN, W. EARL
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [AIAA PAPER 87-2120] p 93 A87-50197
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet [NASA-TM-88854] p 98 N87-22237
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [NASA-TM-100113] p 98 N87-23821
Water-propellant resistojets for man-tended platforms [NASA-TM-100110] p 99 N87-26135

MORRIS, EDGAR E.
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results [AIAA PAPER 87-2157] p 160 A87-45441

MORRIS, J.
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002

MORSE, T. W.
High speed simulation of multi-flexible-body systems with large rotations [AIAA PAPER 87-0930] p 57 A87-33730

MORTENSEN, A. J.
Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-20311

MORY, R.
Space Station - Overview of the European concept of Columbus programme status and content p 145 A87-32528
From Eureca-A to Eureca-B p 155 A87-53916

MORY, ROBERT
Eureca - A first step towards the Space Station p 146 A87-32537

MOSER, DIANE
A question of gravity p 1 A87-32116

MOSTAFA, OSAMA ABDERRHMAN
Variable structure control system maneuvering of spacecraft p 94 N87-21988

MOTLEY, R. W.
Ground-based studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams p 109 N87-26200

MOTOHASHI, SHOICHI
The design and development of a two-dimensional adaptive truss structure p 40 N87-26860

MUEHLBAUER, K.
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20368

MUFTI, I. H.
Model reference adaptive control for large structural systems p 63 A87-52973

MUIR, ARTHUR H., JR.
Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 136 N87-20306

MUKERJEE, AMITABHA
Self-calibration strategies for robot manipulators p 102 N87-26355

MURAKAMI, MASAAKI
A thermally-pumped heat transport system p 40 A87-32369

MURATORE, J.
Space Station Information System integrated communications concept [AIAA PAPER 87-2228] p 114 A87-48606
Space Station Information System requirements for integrated communications [AIAA PAPER 87-2229] p 114 A87-48607

MUROTSU, Y.
Low-authority control of large space structures by using tendon control system [AIAA PAPER 87-2249] p 60 A87-50413

MUROTSU, YOSHISADA
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37853

MURPHY, GEORGE L.
Space Station galley design [SAE PAPER 860932] p 119 A87-38722

MURRAY, J.
Space station structural dynamics/reaction control system interaction study p 67 N87-22753

MURRAY, N. D.
Information network architectures p 116 N87-29149
Video image processing p 116 N87-29150

MURRAY, R. F.
Electronic control/display interface technology p 88 N87-29161

MURRAY, R. W.
Integrated waste and water management system [SAE PAPER 860998] p 51 A87-38773

MYRON, D. L.
Development of a prototype two-phase thermal bus system for Space Station [AIAA PAPER 87-1628] p 44 A87-43128

N

NAGATOMO, MAKOTO
Concept design and cost estimation of a free-flying space platform p 146 A87-32539

NAGEM, RAYMOND J.
Wave-mode coordinates and scattering matrices for wave propagation [AD-A176888] p 29 N87-21030
Comparison of wave-mode coordinate and pulse summation methods [AD-A177795] p 30 N87-21892
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures) [AD-A177271] p 30 N87-22258

NAIDU, D. S.
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure [AIAA PAPER 87-0895] p 16 A87-33889

NAKAGAWA, J.
A master-slave manipulator system for space use p 147 A87-32546

NAKAJIMA, TAKASHI
Concept design and cost estimation of a free-flying space platform p 146 A87-32539

NAKAMARU, KUNIO
Structural design and component tests of large geostationary satellite bus p 144 A87-32335

NAKAMURA, KENJI
Observation of precipitation from space by the weather radar p 145 A87-32507

NAKAMURA, TATSUSABURO
Thermal verification method for large sized spacecraft p 144 A87-32368

NAKAMURA, YASUO
Development of fluid loop system for spacecraft p 144 A87-32370

NAKAMURA, YOSHIHIRO
Solar concentrator system for experiments in the Space Station p 146 A87-32536

NAKAMURA, SEIICHI
System and operation analyses of OTV Network - A new space transportation concept p 145 A87-32475

NAKAYAMA, K.
A master-slave manipulator system for space use
p 147 A87-32546

NAPOLITANO, L. G.
Space: New opportunities for all people; Selected Proceedings of the Thirty-seventh International Astronautical Congress, Innsbruck, Austria, Oct. 4-11, 1986 p 168 A87-41566

NAPOLITANO, LUIGI G.
Tether system and controlled gravity
[AAS PAPER 86-240] p 124 A87-38573

NARUSE, T.
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443

NASAR, S. A.
Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-39735

NATORI, M.
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340

NATORI, MICHIHIRO
Model study of simplex masts p 144 A87-32339
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341
Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 148 A87-33867
The design and development of a two-dimensional adaptive truss structure p 40 N87-29860

NAVE, L. H.
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1856] p 91 A87-45255

NAYFEH, A. H.
The effect of nonlinearities on flexible structures
[AD-A181736] p 38 N87-27259

NEEDHAM, BRUCE H.
Operational instruments on the Space Station-Polar Platforms - Contributions by NOAA and the international community p 127 A87-53149

NEILL, D. J.
ASTROS - A multidisciplinary automated structural design tool
[AIAA PAPER 87-0713] p 6 A87-33557

NELEPO, YE.
Status of orbital astronomy projects
p 128 N87-21973

NELSON, J. M.
Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179167] p 4 N87-28583

NELSON, ROBERT W.
Advanced software tools space station focused technology p 5 N87-29164

NESMAN, T. E.
SAFE/DAE: Modal test in space p 77 N87-20584

NESMITH, B.
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 76 A87-41145

NETTER, G.
Demands imposed on a surface tension propellant tank due to refuelability in the microgravity environment of outer space
[DGLR PAPER 86-104] p 88 A87-36756

NEVERMAN, DALE A.
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results
[AIAA PAPER 87-2157] p 160 A87-45441

NEVINS, J. L.
An integrated approach to spacecraft design for robotic servicing
[AIAA PAPER 87-1672] p 100 A87-41152

NEWBOLD, DAVID D.
A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 860984] p 50 A87-38783

NGUYEN, CHARLES C.
Control of robot manipulator compliance
p 100 A87-45797

NGUYEN, DUC T.
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 6 A87-33560

NGUYEN, TONY H. Q.
1987 status report - United States Air Force electric propulsion research and development
[AIAA PAPER 87-1088] p 90 A87-41122

NICHOLS, THOMAS B.
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583

NIEDBAL, N.
Modal-survey testing for system identification and dynamic qualification of spacecraft structures
p 27 N87-20365
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 36 N87-26075

NIEL, M.
The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-38443

NIEWOOD, ELI
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583

NILSEN, PETER W.
A cost effective 300 Mbps space-to-ground communications subsystem for the Space Station program p 113 A87-45521

NISHIMURA, MAKOTO
Evaluation testing of a mechanical actuator component operating in a simulated space environment
p 160 A87-32549

NISHIOKA, KENJI
An astrometric facility for planetary detection on the Space Station p 127 A87-50750
An astrometric facility for planetary detection on the space station
[NASA-TM-89436] p 128 N87-20841

NITTA, KEIJI
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455
Gas and water recycling system for IOC vivarium experiments p 46 A87-32457
Water recycling for Space Station p 46 A87-32459

NIXON, DAVID
Space station group activities habitability module study
[NASA-CR-4010] p 165 N87-21585

NOGUCHI, NAOKI
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-32547

NOLAN, MARK B.
Advanced technology for the Space Station
p 120 A87-40353

NOMURA, SHIGEAKI
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540

NOOR, AHMED K.
Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures
[NASA-CR-4089] p 40 N87-29869

NORED, DONALD L.
Manned spacecraft electrical power systems
p 75 A87-37291

NORMAN, A. M.
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1856] p 91 A87-45255
Space station propulsion test bed: A complete system
p 98 N87-29131

NORRIS, M. A.
Control of distributed structures with small nonproportional damping
[AIAA PAPER 87-2250] p 60 A87-50414

NORRIS, MARK A.
Sensitivity of distributed structures to modal order in feedback control
[AIAA PAPER 87-0800] p 58 A87-33710

NORTON, D. J.
Symposium on Microgravity Fluid Mechanics, Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 p 69 A87-35786

NOVAK, MICHAEL J.
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583

NOYES, GARY P.
An advanced carbon reactor subsystem for carbon dioxide reduction
[SAE PAPER 860995] p 51 A87-38772

O

O'DONNELL, K. J.
Incorporation of the effects of material damping and nonlinearities on the dynamics of space structures
p 21 A87-42075

OBAL, M. W.
Optimal vibration control by the use of piezoceramic sensors and actuators
[AIAA PAPER 87-0958] p 18 A87-33751

OBAL, MICHAEL WALTER
Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-25367

OBATA, A.
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340

OBAYASHI, T.
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521

OBERRIGHT, JOHN E.
Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860973] p 134 A87-38755

ODA, KERI L.
Degradation studies of SMRM teflon
p 108 A87-38641

OERY, H.
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 36 N87-26075

O'FLAHERTY, PATRICK
Commercialization of space - The insurance implications p 166 A87-32480

OGUCHI, MITSUO
Gas and water recycling system for IOC vivarium experiments p 46 A87-32457

OGUCHI, TETSURO
A thermally-pumped heat transport system
p 40 A87-32369

OHATA, KOHEI
Thermal deformation and electrical degradation of antenna reflector with truss backstructure
p 12 A87-32435

OHKAMI, YOSHIAKI
Local control for large space structures
p 54 A87-32440
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
Space Station program in a long-range space development scenario of Japan p 145 A87-32530
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534

OHKAWA, KOHEI
Evaluation testing of a mechanical actuator component operating in a simulated space environment
p 160 A87-32549

OHNISHI, AKIRA
Thermal verification method for large sized spacecraft
p 144 A87-32368

OHTA, TOSHIHIKO
Development of exposed deck of Japanese experiment module p 145 A87-32532

OHTSUBO, KOHJI
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455

OJIMA, YOSHIKAZU
Development of graphite epoxy space structure
p 105 A87-32342

OKADA, HIROO
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-37953

OKAMOTO, KENICHI
Observation of precipitation from space by the weather radar p 145 A87-32507

OKAMOTO, OSAMU
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447

OKAMURA, T.
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-39928
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-39929

OKAZAKI, K.
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340

OKAZAKI, KAKUMA
Model study of simplex masts p 144 A87-32339

OKUBO, H.
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2349] p 60 A87-50413

OKUDA, KAZUMI
Structural design and component tests of large geostationary satellite bus p 144 A87-32335

OLDSON, JOHN C.
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40810

248

OLEN, CARL
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 131 N87-25188
OLESON, MELVIN W.
CELSS waste management systems evaluation
[SAE PAPER 860997] p 51 A87-36774
OLSEN, R. C.
Potential modulation on the SCATHA spacecraft
p 139 A87-34480
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A176815] p 140 N87-21024
Electron beam experiments at high altitudes
p 142 N87-29046
OLSEN, RICHARD C.
Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22506
OLSEN, ROY E.
Advanced orbital servicing capabilities development
[SAE PAPER 860982] p 134 A87-36789
OLSON, NANCI A.
Space Station multiple access communications system p 86 A87-45524
OLSON, RICHARD L.
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-36757
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-36782
OLSZEWSKI, M.
Application of advanced flywheel technology for energy storage on space station
[DE87-007657] p 68 N87-24029
OLSZEWSKI, MITCHELL
Application of advanced flywheel technology for energy storage on space station p 74 N87-29853
ONA, AKIRA
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540
ONODA, JUNJIRO
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33610
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0888] p 14 A87-33652
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-34487
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46780
ORANC, B. TARIK
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
ORIENT, OTTO J.
Variable energy, high flux, ground-state atomic oxygen source
[NASA-CASE-NPO-16640-1-CU] p 8 N87-21051
ORTON, GEORGE F.
Analytical and experimental modeling of zero/low gravity fluid behavior
[AIAA PAPER 87-1865] p 91 A87-45280
Propellant tank resupply system
[AD-D012609] p 93 N87-20375
OSBORN, J. R.
A two-dimensional numerical heat transfer model for a solar propulsion system p 74 A87-32508
OSBORN, JIM
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21687
OSHMAN, YAAKOV
Square root state estimator for large space structures
[AIAA PAPER 87-2389] p 24 A87-50475
OSIPYAN, YU.
Progress in theory, technology of space materials science p 159 N87-27685
OSMANSKI, J. T.
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21687
OSTROW, H.
Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS
p 128 A87-44188
OTAGURO, W. S.
Fiber-optic monitors for space structures
p 11 A87-21508
OTSUBO, KOJI
Gas and water recycling system for IOC vivarium experiments p 48 A87-32457
OTSUJI, K.
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station
p 46 A87-32544
OTTO, G.
Scientific user requirements for microgravity research (European aspects)
[AIAA PAPER 87-2195] p 153 A87-49581
OWEN, JAMES W.
Prototype thermal bus for manned Space Station compartments
[SAE PAPER 861825] p 41 A87-32988
Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 89 A87-36779
OWEN, R. G.
A microgravity isolation mount p 161 N87-29881
OWENS, A. R.
A microgravity isolation mount p 161 N87-29881
OWENS, WILLIAM R.
An integrated analytic tool and knowledge-based system approach to aerospace electric power system control
[SAE PAPER 861622] p 74 A87-32579
OYAMA, K. I.
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
OZGUNER, U.
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445

P

PABICH, PAUL J.
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A178897] p 120 N87-22762
PACK, HOMER C., JR.
Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 83 N87-20380
PADULA, S. L.
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33611
PAILLOUS, ALAIN
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32348
PALASZEWSKI, B.
Geosynchronous earth orbit base propulsion - Electric propulsion options
[AIAA PAPER 87-0990] p 89 A87-38004
PALETTA, F.
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration
p 83 N87-28808
PANICHKIN, NIKOLAI IVANOVICH
Structure and design of spacecraft
p 155 A87-51870
PANOSSIAN, HAGOP V.
An assessment of recent advances in modeling and control design of space structures under uncertainty
[SAE PAPER 861818] p 147 A87-32988
PAQUET, P.
Solid Earth panel report p 157 N87-28838
PARADISO, JOSEPH A.
A highly adaptable steering/selection procedure for combined CMG/RCS spacecraft control
[AAS PAPER 86-036] p 58 A87-32741
PARCELIER, MICHEL
PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44559
PARISH, R. C.
Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1628] p 44 A87-43128
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1646] p 44 A87-44843
PARISH, RICHARD C.
Microgravity fluid management in two-phase thermal systems p 95 N87-21152
PARK, K. C.
Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33729
PARKER, IAN
The SERVICE concept p 134 A87-36802
PARKER, L. W.
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved
p 142 N87-29049
PARKS, D. E.
Theory of plasma contactors for electrodynamic tethered satellite systems p 65 A87-41609
PARRISH, R. V.
Electronic control/display interface technology
p 68 N87-29161
PASSERON, L.
Dynamic modeling and optimal control design for large flexible space structures p 28 N87-20358
PATTERSON, MICHAEL
Electrodynamic tether p 131 N87-29449
PATTERSON, MICHAEL J.
Hollow cathode-based plasma contactor experiments for electrodynamic tether
[AIAA PAPER 87-0572] p 121 A87-32182
PAUL, S. F.
Ground-based studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26230
PAVLINSKY, J. F.
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1858] p 91 A87-45255
PAWLIK, EUGENE V.
JPL future missions and energy storage technology implications p 84 N87-29617
PAYRES, G.
Modeling, stabilization and control of serially connected beams p 21 A87-41052
PEARCE, TONY B.
Composite fiber/metal Space Station tankage - Applications, material/process/design trades, and subscale manufacturing/test results
[AIAA PAPER 87-2157] p 160 A87-43441
PEARSON, RICHARD
Optimization of heat rejection subsystem for solar dynamic Brayton cycle power system
[SAE PAPER 860999] p 43 A87-36776
PEDERSEN, K.
Data management system architecture options for space stations
[SES/DNP/TR/302/85] p 115 N87-28585
PELENC, L.
Aerospatiale solar arrays, in orbit performance
p 159 N87-28869
PENN, JAY P.
Electric propulsion for orbit transfer - A NAVSTAR case study (Has electric propulsion's time come?)
[AIAA PAPER 87-0985] p 89 A87-38001
PENZO, PAUL A.
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 123 A87-38867
A survey of tether applications to planetary exploration
[AAS PAPER 86-200] p 125 A87-38888
PEPLINSKI, DANIEL R.
Laboratory studies of atomic oxygen reactions with solids p 4 N87-29165
PERCHONOK, MICHELE G.
Space Station Food System
[SAE PAPER 860950] p 48 A87-36730
PEREZHOGIN, A. A.
Stability in the relative equilibrium positions of space stations at triangular libration points in the photogravitational three-body problem p 1 A87-32802
PERKINS, DOROTHY C.
Standards for the user interface - Developing a user consensus
[AIAA PAPER 87-2200] p 169 A87-49584
PERKINS, W. A.
Complex system monitoring and fault diagnosis using communicating expert systems p 119 A87-43233
PETERKA, D. L.
Documentation for the SHADO particle orbit routine
[AD-A181501] p 131 N87-28987
PETERSON, CHRIS
Design of a robust fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-23833
PETERSON, G. P.
Determination of the cross-sectional temperature distribution and boiling limitation of a heat pipe
p 45 A87-52175
PETERSON, LEE D.
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement
p 94 N87-21147
PETERSON, R. V.
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182001] p 110 N87-28709

PFEIFER, KARL
Stress and deformation analysis of lightweight composite structures
[MBB-UD-489/86] p 30 N87-22299

PFEIFFER, B.
The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 129 N87-20622
Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects) p 129 N87-20631
Panel report on the polar platform servicing approach and its implications p 136 N87-20641

PHILIPPON, J. P.
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit p 156 N87-26953

PHILLIPS, CHARLES L.
Improving stability margins in discrete-time LQG controllers p 31 N87-22719

PHILLIPS, ELIZABETH B.
User interface design guidelines for expert troubleshooting systems p 6 A87-33050

PIERSON, DUANE L.
Results on reuse of reclaimed shower water
[SAE PAPER 880985] p 50 A87-38762
Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27392

PILKEY, W. D.
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 80 A87-50415
Suboptimal feedback vibration control of a beam with a proof-mass actuator
[AIAA PAPER 87-2323] p 23 A87-50444

PILMANIS, ANDREW A.
Hyperbaric oxygen therapy for decompression accidents - Potential applications to Space Station Operation
[SAE PAPER 880927] p 163 A87-38717

PINNAMANENI, B.
Space station structural dynamics/reaction control system interaction study p 87 N87-22753

PINSON, E. D.
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 36 N87-25808

PINSON, LARRY D.
Future trends in spacecraft design and qualification p 2 N87-20356

PIPPIN, H. GARY
Structure-property relationships in polymer resistance to atomic oxygen p 108 A87-38842
Comments on the interaction of materials with atomic oxygen p 110 N87-26206

PISTER, KARL S.
An integrated, optimization-based approach to the design and control of large space structures
[AD-A179458] p 34 N87-23683

PITT, RICHARD
Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-162] p 90 A87-42880

PLAGGE, A.
The high performance solar array GSR3 p 81 N87-20072

PLANET, WALTER
Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25889

PLEVIN, JOHN
Space Station opportunity for UK in earth sensing p 152 A87-41879

PLUSSAT, Y.
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 88 N87-20350

PLUMMER, S. E.
A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K. p 125 A87-41430

POELSTRA, J.
A study of fluid transfer management in space
[FTMS-RPT-005] p 97 N87-26869

POH, S.
Modified independent modal space control method for active control of flexible systems
[NASA-CR-181085] p 34 N87-23580
A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181100] p 35 N87-25005
Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-28715
Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-28865

POHER, CLAUDE
ERATO orbital transfer vehicle with electronuclear power Study of the associated electronuclear generator p 75 A87-36944

POKROVSKIY, A.
Pravda commentary, photos of Mir orbital station p 158 N87-27686

POLAK, ELIJAH
An integrated, optimization-based approach to the design and control of large space structures
[AD-A179458] p 34 N87-23683

POLITANSKY, H.
The control of linear dampers for large space structures
[AIAA PAPER 87-2251] p 80 A87-50415
Suboptimal feedback vibration control of a beam with a proof-mass actuator
[AIAA PAPER 87-2323] p 23 A87-50444

PONMAN, T. J.
Coded mask telescopes for X-ray astronomy p 123 A87-37786

POORAN, FARHAD J.
Control of robot manipulator compliance p 100 A87-45797

POSPIESZCZYK, H. J.
Evolution of data management systems from Spacelab to Columbus
[AIAA PAPER 87-2227] p 154 A87-49805

POST, RICHARD S.
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23098

POWELL, F. T.
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 880994] p 51 A87-38771

POWELL, J. R.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

POWELL, JIM D.
Control/monitor instrumentation for environmental control and life support systems aboard the Space Station
[SAE PAPER 881037] p 52 A87-38779

POWERS, ROBERT B.
Optimization of payload mass placement in a dual keel space station
[NASA-TM-89061] p 88 N87-23687

PRADEEP, S.
Stability of time varying linear systems p 7 A87-37136

PRALL, JOHN E., JR.
Thermal and dynamical effects on electrodynamic space tethers
[AD-A180276] p 130 N87-25351

PRASAD, VENKATESH
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures
[NASA-CR-180917] p 38 N87-27280

PRATT, MARTIN L.
An evolutionary approach to the development of a CELSS based air revitalization system
[SAE PAPER 880995] p 49 A87-38750

PREISS, H.
Columbus Life Support System and its technology development
[SAE PAPER 880980] p 150 A87-38748

PRILEAN, STEPHEN E.
Space Station personal hygiene study
[SAE PAPER 880931] p 163 A87-38721

PREMACK, TIMOTHY
Control of robot manipulator compliance p 100 A87-45797

PRENGER, F. C.
Magnetic refrigeration for space platforms
[SAE PAPER 861734] p 116 A87-32813

PREUMONT, ANDRE
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0303] p 17 A87-35712

PRICE, C. R.
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-89221] p 137 N87-25333

PRICE, DONALD F.
A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 880994] p 50 A87-38763

PRICE, HAROLD G.
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 98 N87-29133

PRICE, LARRY
Space Station EVA systems trade-off model
[SAE PAPER 880890] p 134 A87-38707

PRIMEAUX, GARY R.
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 880968] p 164 A87-38751
Concepts for the evolution of the Space Station Program
[SAE PAPER 880972] p 120 A87-38754

PUE, A. J.
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236

PULLIAM, ROBERT
Use of heads-up displays, speech recognition, and speech synthesis in controlling a remotely piloted space vehicle p 99 A87-31480
A simulation capability for future space flight
[SAE PAPER 861784] p 99 A87-32833

PURVIS, CHRISTOPHER
Tether power supplies exploiting the characteristics of space
[AAS PAPER 86-227] p 123 A87-36571

PUTNAM, DAVID F.
Pre- and post-treatment techniques for spacecraft water recovery
[SAE PAPER 880982] p 50 A87-38761
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs
[SAE PAPER 880987] p 51 A87-38766

PYLE, JON S.
Control of flexible structures and the research community p 88 N87-22732

Q

QUEIJO, M. J.
An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20340

QUINN, ALBERTA
Advanced orbital servicing capabilities development
[SAE PAPER 880982] p 134 A87-38769

QUINN, R. D.
Equations of motion for maneuvering flexible spacecraft p 63 A87-52666
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734

R

RAASCH, W.
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373

RACHKOV, A. V.
Shape control of the directional pattern in a microwave-beam power transmission channel p 148 A87-34345
The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35766

RADKE-MITCHELL, LYN
A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 880994] p 50 A87-38763

RADKE, KATHLEEN
Head-ported display analysis for Space Station applications p 111 A87-21483

RAHMAT-SAMII, Y.
Antenna Technology Shuttle Experiment (ATSE) p 87 N87-24509

RAJAN, S. D.
A hybrid nonlinear programming method for design optimization p 7 A87-35718

RAMBAUT, PAUL C.
Foods and nutrition in space
[SAE PAPER 880926] p 47 A87-38716

RANEY, WILLIAM P.
The Space Station overview p 169 A87-41571

RANKIN, J. GARY
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125

RANTANEN, R.
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4091] p 53 N87-28099

RASMUSSEN, DARYL N.
Life Sciences Research Facility automation requirements and concepts for the Space Station
[SAE PAPER 880976] p 50 A87-38752

RASMUSSEN, R. D.
MAX: A space station computer option p 116 N87-29146

RASOULI, F.
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 880985] p 50 A87-38764

RATLIFF, JAMES E.
FDMA system design and analysis for Space Station
p 85 A87-45483
RAU, TIMOTHY R.
Technical and Management Information System (TMIS)
[AIAA PAPER 87-2217] p 114 A87-49600
RAULT, R.
Ariane transfer vehicle (ATV) to supply Space Station
[AIAA PAPER 87-1862] p 152 A87-45257
RAY, ART J.
Rendezvous and docking tracker
[AAS PAPER 86-014] p 133 A87-32733
RAY, C. D.
Status of the Space Station environmental control and life support system design concept
[SAE PAPER 860943] p 48 A87-38730
RAY, RODERICK J.
A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 860984] p 50 A87-38763
RAYBURN, STEVEN D.
Development of a standard connector for orbital replacement units for serviceable spacecraft
p 40 N87-29864
RAZZAQ, ZIA
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures
[NASA-CR-180317] p 38 N87-27260
READ, J. Y.
Complex system monitoring and fault diagnosis using communicating expert systems p 119 A87-40363
REDD, L. R.
Propulsion recommendations for space station free flying platforms p 88 N87-26129
REDDY, A. S. S. R.
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712
REED, D. K.
SAFE/DAE: Model test in space p 77 N87-20584
REEVES, MURRAY
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-48882
REGAL, DAVID M.
Human performance in space p 162 A87-33021
REICHERT, R. G.
Space launcher upper stages - Design for mission versatility and/or orbital operation p 132 A87-32474
REICHERT, RUDI G.
Europe prepares for manned orbital operations
p 151 A87-38584
REICHL, KARL O., JR.
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182069] p 81 N87-28188
REINHARTZ, K.
Space 2000 in Europe p 159 N87-29024
REITZ, G.
The problem of radiation exposure in the Space Station
[DGLR PAPER 86-175] p 153 A87-48157
REMPT, RAYMOND D.
Production of a beam of ground state oxygen atoms of selectable energy p 139 A87-38824
RENNER, H.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412
RENNER, RONALD E.
An evaluation of advanced extravehicular crew enclosures
[SAE PAPER 861028] p 134 A87-38781
RENNER, U.
Demands imposed on a surface tension propellant tank due to refuellability in the microgravity environment of outer space
[DGLR PAPER 86-104] p 88 A87-38758
RETICCIOLI, B.
Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-29004
RETZLAFF, SANDRA E.
A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 860984] p 50 A87-38763
REULEY, R.
MARECS and ECS anomalies: Attempt at irradiation defect production in Kapton p 82 N87-29880
REUTER, JAMES L.
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-38729
REYSA, RICHARD P.
Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 50 A87-38762
RHEA, JOHN
Space Station - All change? p 154 A87-50792
RHODES, G. D.
Environmental avoidance concepts for steerable Space Station radiators
[SAE PAPER 861831] p 41 A87-32865
RHODES, MARVIN D.
Deployable geodesic truss structure
[NASA-CASE-LAR-13113-1] p 36 N87-25492
Preloaded space structural coupling joints
[NASA-CASE-LAR-13489-1] p 38 N87-27713
RICE, JOHN R.
Planning for unanticipated satellite servicing teleoperations p 118 A87-33048
RICHARDS, KEN
Optimum mix of passive and active control of space structures p 65 N87-22714
RICHARZ, H. P.
The evolution of a serviceable EURECA
[MBB-UR-E-923/86] p 121 N87-29841
RICHTER, G. PAUL
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 89 N87-26133
RIEMER, DAVID H.
Space station experiment definition: Long-term cryogenic fluid storage p 94 N87-21144
RIGSBY, JOHN B.
Habitability issues for the Science Laboratory Module
[SAE PAPER 860971] p 50 A87-38753
RIMROTT, F. P. J.
Global treatment of energy dissipation effects for multibody satellites p 62 A87-51610
ROBERTS, G.
A microgravity isolation mount p 161 N87-29881
ROBERTSON, ANDREW R.
Development of precision structural joints for large space structures p 28 N87-20374
ROBINSON, A. A.
A microgravity isolation mount p 161 N87-29881
ROBSON, R. R.
Automatic charge control system for geosynchronous satellites p 87 N87-29880
ROCHON, BRIAN V.
Crew activity and motion effects on the space station
p 165 N87-22744
RODDEN, J. J.
Vibration isolation for line of sight performance improvement p 67 N87-22742
RODRIGUEZ, G.
Static shape control for flexible structures
[SAE PAPER 861822] p 13 A87-32858
ROEBELEN, GEORGE J.
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734
ROEBELEN, GEORGE J., JR.
Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 89 A87-38776
ROGERS, LESLIE J. A.
The next step for the MMU - Capabilities and enhancements
[SAE PAPER 861013] p 160 A87-38783
ROGERS, LYNN
Optimum mix of passive and active control of space structures p 65 N87-22714
ROGERS, R. P.
A model for the estimation of the operations and utilization costs of an international space station
p 168 A87-42267
ROLAND, ALEX
We shouldn't build the Space Station now
p 169 A87-46875
ROLFE, E. J.
Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-268] p 129 N87-20821
ROMERO, E.
A study of fluid transfer management in space
[FTMS-RPT-009] p 97 N87-26088
ROMERO, JAMES M.
Large space systems technology and requirements
p 3 N87-24500
ROSE, L. J.
Propulsion recommendations for space station free flying platforms p 88 N87-26129
ROSE, T.
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33758
ROSE, T. L.
Structural dynamics system model reduction
p 32 N87-22727
ROSENDHAL, JEFFREY D.
A crisis in the NASA space and earth sciences programme p 112 A87-37968
ROSS, SUSAN E.
Rendezvous and docking tracker
[AAS PAPER 86-014] p 133 A87-32733
ROSSIER, ROBERT N.
Nuclear powered submarines and the Space Station - A comparison of ECLSS requirements
[SAE PAPER 860945] p 45 A87-38732
ROTH, H.
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
ROTT, M.
Micrometeorite exposure of solar arrays
p 82 N87-29862
ROUX, CH.
Computer simulation of deployment
p 10 N87-29002
RUDEV, A. I.
Legal problems concerning manned space flight
p 151 A87-40336
RUDIGER, C. E.
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860953] p 164 A87-38740
RUDIGER, CARL E.
Special considerations in outfitting a space station module for scientific use
[SAE PAPER 860958] p 164 A87-38741
RUDLAND, R. S.
On-orbit cryogenic fluid management experimental data requirements using referee fluids
[AIAA PAPER 87-1558] p 90 A87-44832
RULEV, D. N.
Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34209
Optimizing experimental programs in operational planning of research carried out from spacecraft
p 160 N87-29553
RUPPE, HARRY O.
Thoughts on Europe's future in space
p 151 A87-41219
RUSAKOV, B. B.
Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870
RUSH, T.
Analysis of Intelsat V flight data
[AIAA PAPER 87-0794] p 16 A87-33679
RUSSELL, W. C.
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33709
High speed simulation of multi-flexible-body systems with large rotations
[AIAA PAPER 87-0930] p 57 A87-33730
Dynamics of trusses having nonlinear joints
p 32 N87-22724
RUSSO, GENNARO
Tether system and controlled gravity
[AAS PAPER 86-240] p 124 A87-38573
RUTLEDGE, SHARON
An evaluation of candidate oxidation resistant materials for space applications in LEO
[NASA-TM-100122] p 107 N87-25480
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation
p 131 N87-26188
An evaluation of candidate oxidation resistant materials p 110 N87-26203
RYAN, ROBERT S.
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-1] p 65 N87-22702
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 68 N87-22729

S

SAGAN, CARL
Prospects for space science
[AAS PAPER 86-105] p 170 A87-53088
SAINZ, M.
Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-49588
SAITO, M.
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41579

SAITOU, M.
Status of Japanese Experiment Module design
p 145 A87-32531
SAKAI, JIRO
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
SAKAMAKI, MASANORI
Model study of simplex masts p 144 A87-32339
SAKAMOTO, N.
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48802
SAKATANI, YOSHIAKI
Development of full scale deployable CFRP truss for space structure p 25 A87-51793
SAKURAI, YASUSHI
A thermally-pumped heat transport system
p 40 A87-32369
SALAMA, M.
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33755
SALAMI, KARIM G.
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 30 N87-22256
SALIMOV, G. R.
Effect of crew motions on the spatial position of a spacecraft p 152 A87-41954
SALOMONSON, V. V.
Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS
p 128 A87-44186
SALONEN, ERKKI
Design of a beacon receiving system for the Olympus satellite p 88 A87-50157
SAMSON, P.
Aerospatiale solar arrays, in orbit perfor[illegible]
p [illegible] [illegible]
SANDERS, FRED G.
B-stem gripping apparatus
[NASA-CASE-MFS-28185-1] p 107 N87-25586
SANDRIDGE, CHRIS A.
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0805] p 57 A87-33714
SARG, G. TRAN
Vapor fragrancer
[NASA-CASE-LAR-13680-1] p 165 N87-25081
SARKAR, T. S.
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20589
SANTORU, J.
Automatic charge control system for geosynchronous satellites p 87 N87-26860
SANTOS-MASON, B.
Selected materials issues associated with Space Station p 106 A87-32361
SANTOSMASON, B.
Review of Low Earth Orbital (LEO) flight experiments
p 131 N87-28174
SARIGUL, NESRIN
Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-22311
SARLO, L.
The hardware/software architecture of the Columbus pressurized module element
[AIAA PAPER 87-2211] p 154 A87-48888
SARRAIL, D.
On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit
p 158 N87-26853
MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-26860
SARYCHEV, V. A.
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801
SASAKI, H.
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-38828
SASAKI, S.
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-52521
SATO, S.
Design consideration of mechanical and deployment properties of a collable lattice mast p 12 A87-32340
SATOU, S.
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station
p 46 A87-32544
SATTERTHWAITE, ROBERT E.
Space Station and effector strategy study
[NASA-TM-100483] p 103 N87-26883
SAUER, R. L.
Integrated waste and water management system
[SAE PAPER 860996] p 51 A87-36773
SAUER, RICHARD L.
Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27392
SAVAGE, TERRY R.
An operations management system for the Space Station p 112 A87-40258
SAW, KONG C.
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts
p 19 A87-35327
SAWADA, T.
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station
p 46 A87-32544
SAWDON, F. E.
Design of a polar platform with an earth observation payload p 122 A87-32536
SAZONOV, V. V.
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32801
SCARGLE, JEFFREY D.
An astrometric facility for planetary detection on the Space Station p 127 A87-50750
An astrometric facility for planetary detection on the space station
[NASA-TM-89438] p 128 N87-23841
SCARLOTTI, R. D.
Space station experiment definition: Long-term cryogenic fluid storage
[NASA-CR-4072] p 97 N87-24841
SCHAEFER, B.
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2381-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2381-VOL-1] p 73 N87-27707
SCHAMEL, GEORGE C., II
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 58 A87-33713
An analytical and experimental investigation of output feedback vs. linear quadratic regulator
[AIAA PAPER 87-2390] p 61 A87-50474
SCHAPERY, R. A.
Dynamic response of a viscoelastic Timoshenko beam
[AIAA PAPER 87-0890] p 18 A87-33705
SCHEDLER, ARMIN
Fiber composites in satellites
[MBB-UD-489/86] p 107 N87-25430
SCHEER, STEVEN A.
Crew activity and motion effects on the space station
p 165 N87-22744
SCHEID, R. E., JR.
Static shape control for flexible structures
[SAE PAPER 861822] p 13 A87-32858
SCHELKOPF, J. D.
Science Research Facilities - Versatility for Space Station
[SAE PAPER 860938] p 119 A87-36742
SCHILDT, U.
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20588
SCHLUDE, F.
European utilization aspects studies
p 158 N87-20624
SCHMID, M.
The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-20612
SCHMIDT, GEORGE R.
The impact of integrated water management on the Space Station propulsion system
[AIAA PAPER 87-1864] p 91 A87-45250
SCHMIDT, J. T.
Active vibration damping of flexible structures using the traveling wave approach p 71 N87-25358
SCHMIDT, ROSEMARY
Space station active thermal control system modeling
[AIAA PAPER 87-1469] p 43 A87-43005
SCHMIT, L. A.
Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0748] p 58 A87-33573
SCHNEIDER, D. W.
Effect of transverse shearing forces on buckling and postbuckling of delaminated composites under compressive loads
[AIAA PAPER 87-0877] p 106 A87-33659
SCHNEIDER, E.
Micrometeorite impact on solar panels
p 82 N87-20601
SCHNEIDER, STEVEN J.
Space station propulsion system technology
[NASA-TM-100108] p 97 N87-25422
SCHOCK, RICHARD W.
Solar array flight dynamic experiment
[AAS PAPER 86-050] p 75 A87-32747
Solar array flight dynamic experiment
p 76 N87-22722
SCHOLTZ, R.
GPS applications to the Space Station
p 138 A87-45525
SCHRANTZ, P. R.
Analysis of Intelsat V flight data
[AIAA PAPER 87-0784] p 16 A87-33679
SCHREINER, K. E.
Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88928] p 88 N87-23690
SCHUNK, RICHARD G.
Space Station environmental control and life support system distribution and loop closure studies
[SAE PAPER 860942] p 48 A87-36729
SCHUSTER, JOHN R.
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1489] p 90 A87-43027
Long term cryogenic storage facility systems study
p 94 N87-21143
SCHWARTZ, D.
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002
SCHWARTZ, M. R.
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-36732
SCHWARZ, B.
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860938] p 42 A87-36725
SCHWEICKERT, THOMAS F.
Propellant tank resupply system
[AD-D012588] p 93 N87-20375
SCHWENDE, MANFRED
Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-182] p 90 A87-42680
SCOFIELD, HAROLD N.
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-1] p 66 N87-22702
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 69 N87-22729
SCOTT-MONCK, JOHN
Advanced photovoltaic solar array design assessment
p 80 N87-29429
SEARS, WILLIAM J.
Physiological aspects of EVA
[SAE PAPER 860981] p 164 A87-36768
SEETHARAMABHAT, M.
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25356
SERAFINI, JOHN S.
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 92 A87-52252
SERPHAY, R. A.
Frequency dispersion in the admittance of the polycrystalline CuInS/CdS solar cell p 5 A87-29133
SEVERINSEN, B.
Dynamic modeling and optimal control design for large flexible space structures p 29 N87-20589
SHAPLAND, D. J.
The Columbus program: An overview
p 158 N87-20623
SHARKEY, J. P.
Distributed control using linear momentum exchange devices
[NASA-TM-100028] p 70 N87-24521
SHARKEY, JOHN P.
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 6 N87-22735
SHARMA, R.
Actuators for actively controlled space structures
p 59 A87-42816
SHAW, F. H.
Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33706
Dynamics of trusses having nonlinear joints
p 32 N87-22724
Equivalent beam modeling using numerical reduction techniques p 32 N87-22725

252

SHAWCROSS, PAUL J.
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 1 N87-29583
SHEIBLEY, D. W.
Advanced technology for extended endurance alkaline fuel cells p 75 A87-33767
SHEIBLEY, DEAN W.
Status of space station power system p 84 N87-29915
SHELTON, K. W.
Antenna systems and RF coverage for the Space Station p 2 A87-45523
SHENHAR, J.
On-line identification and attitude control for SCOLE [AIAA PAPER 87-2458] p 61 A87-50505
SHIBUYA, YOSHIKAZU
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32398
SHIH, CHOON-FOO
Verification of large beam-type space structures p 31 N87-22712
SHIN, JAEDONG
Gradient-based combined structural and control optimization p 21 A87-40868
SHIMADA, MASAAKI
Communication missions for geostationary platforms p 84 A87-34797
SHIMAMOTO, YOSHIHARU
A preliminary study on a linear inertial actuator for LSS control p 55 A87-32447
SHIMEMURA, ETSUJIRO
A consideration to vibration control for a large space structures p 54 A87-32441
SHISHKIN, VIACHESLAV PAVLOVICH
Structure and design of spacecraft p 155 A87-51870
SHIPLEY, J. W.
The Mast Flight System dynamic characteristics and actuator/sensor selection and location [AAS PAPER 86-003] p 13 A87-32729
SHIRAKI, K.
Status of Japanese Experiment Module design p 145 A87-32531
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41570
SHIRAKI, KUNIAKI
Development of exposed deck of Japanese experiment module p 145 A87-32532
SHOJI, TAKATOSHI
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 46 A87-32455
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
SHOWALTER, DARTON E.
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583
SHRIVASTAVA, S. K.
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25304
SHRIVASTAVA, SHASHI K.
Stability of time varying linear systems p 7 A87-37135
SHUMAN, B. M.
Automatic charge control system for geosynchronous satellites p 87 N87-28880
SHUMATE, TIMOTHY P.
Microcrack resistant structural composite tubes for space applications p 108 A87-41022
SIBENER, STEVEN J.
Dynamics of atom-surface interactions p 141 N87-26183
SIEMERS, P. M., III
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
SIGNORELLI, JOEL
Wave propagation in periodic truss structures [AIAA PAPER 87-0944] p 19 A87-33742
SIGUIER, J. M.
MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-28880
SIMON, WILLIAM E.
Manned spacecraft electrical power systems p 75 A87-37281
SIMONIAN, S. S.
On a balanced passive damping and active vibration suppression of large space structures [AIAA PAPER 87-0901] p 19 A87-34701
SIMONTON, J. WAYNE
Deployable geodesic truss structure [NASA-CASE-LAR-13113-1] p 36 N87-25482
SINGH, R. P.
Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22746
SINGH, S. K.
Comparison of different attitude control schemes for large communications satellites [AIAA PAPER 87-2301] p 61 A87-50475
SINGH, SAHJENDRA N.
Robust nonlinear attitude control of flexible spacecraft p 60 A87-46273
SIRA-RAMIREZ, HEBERTT
Variable structure controller design for spacecraft nutation damping p 58 A87-38858
SIRLIN, SAMUEL W.
The Softmounted Inertially Reacting Pointing System (SIRPNT) [AAS PAPER 86-007] p 56 A87-32732
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42817
SJOLANDER, GARY W.
Martin Marietta atomic oxygen beam facility p 139 A87-26822
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-26204
SKIDMORE, RICHARD A.
A simulation capability for future space flight [SAE PAPER 861784] p 99 A87-32633
SKINNER, G. K.
Coded mask telescopes for X-ray astronomy p 123 A87-37785
SKIRVIN, GLEN D.
Military space station implications [AD-A180831] p 172 N87-25884
SKOOG, A. I.
Columbus Life Support System and its technology development [SAE PAPER 860966] p 150 A87-38748
SKOWRONSKI, J. M.
Adaptive tracking of dynamical model by uncertain nonlinearizable spacecraft [AIAA PAPER 87-0940] p 57 A87-33738
SLATER, G. L.
Robust multivariable control of large space structures using positivity p 59 A87-47810
Construction of positive real compensation for LSS control [AIAA PAPER 87-2238] p 60 A87-50404
SLAVIN, THOMAS J.
CELSS waste management systems evaluation [SAE PAPER 860997] p 51 A87-38774
SLEMP, WAYNE S.
Assessment of space environment induced microdamage in toughened composite materials p 20 A87-38809
SLEPUSHKIN, IURII VALENTINOVICH
Structure and design of spacecraft p 155 A87-51870
SLOVIK, G.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor [DE87-010000] p 99 N87-28405
SMITH, D. B.
MAX: A space station computer option p 116 N87-29149
SMITH, GENE
Data capture and processing [AIAA PAPER 87-2203] p 113 A87-48888
SMITH, KERI ODA
O-atom degradation mechanisms of materials p 141 N87-26178
SMITH, MICHAEL D.
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-40008
SMITH, PAUL H.
Problems in merging Earth sensing satellite data sets [NASA-TM-87820] p 129 N87-22457
SMITH, R. E.
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations [NASA-CP-2460] p 84 N87-20898
SMITH, TERENCE
Remote Sensing Information Sciences Research Group. Santa Barbara Information Sciences Research Group, year 4 [NASA-CR-181073] p 115 N87-24817
SMITH, W.
SAGA: A project to automate the management of software production systems [NASA-CR-180276] p 10 N87-27412
SMITH, WILLIAM L.
Planning for future operational sensors and other priorities [NOAA-NESDIS-30] p 130 N87-25800
SMOLDERS, PETER
Living in space: A handbook for space travellers p 162 A87-33475
SNODDY, WILLIAM C.
Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms [AAS PAPER 86-041] p 133 A87-32743
SOBECK, CHARLIE
Astronomic Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description [NASA-TM-89429-VOL-2] p 129 N87-22570
Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary [NASA-TM-89429-VOL-1] p 129 N87-22571
SOBIESKI, STANLEY
Mass storage systems for data transport in the early space station era 1992-1998 [NASA-TM-87826] p 115 N87-27443
SOBOTTA, WERNER
Control engineering tasks in the framework of the Columbus program [MBB-UR-E-912/86] p 156 N87-26842
SOFFEN, GERALD A.
The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53082
SOILEAU, K. M.
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41815
SOLLY, B.
Science Research Facilities - Versatility for Space Station [SAE PAPER 860958] p 119 A87-38742
SOLON, M.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor [DE87-010000] p 99 N87-28405
SOS, JOHN
Data storage systems technology for the Space Station era [AIAA PAPER 87-2202] p 113 A87-48887
Mass storage systems for data transport in the early space station era 1992-1998 [NASA-TM-87826] p 115 N87-27443
SOULIAC, M.
SPOT/MEGS design and flight results obtained p 103 N87-29909
SOVEY, JAMES S.
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [AIAA PAPER 87-2120] p 93 A87-50187
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet [NASA-TM-89864] p 95 N87-22237
Oxidation protection coatings for polymers [NASA-CASE-LEW-14072-3] p 107 N87-23738
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [NASA-TM-100113] p 96 N87-23821
Space station propulsion system technology [NASA-TM-100108] p 97 N87-25422
Water-propellant resistojets for man-tended platforms [NASA-TM-100110] p 98 N87-26138
SPANGENBURG, RAY
A question of gravity p 1 A87-32116
SPANGLER, L. H.
High intensity 5 eV CW laser sustained O-atom exposure facility for material degradation studies p 106 A87-52890
Mass spectrometers and atomic oxygen p 141 N87-26176
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-26188
SPENCER, MARK B.
Use of lightweight composites for GAS payload structures p 25 N87-26507
SPENCER, PORTER A.
Space Station alpha joint bearing p 83 N87-29882
SPONABLE, JESS M.
Electric propulsion for orbit transfer - A NAVSTAR case study (Has electric propulsion's time come?) [AIAA PAPER 87-0985] p 90 A87-38001
SREENATHA, A. G.
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25304
SRIDHAR, BANAVAR
Maximum likelihood identification using an array processor p 8 A87-32121
SRINIVASAMURTHY, S.
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-22839
ST. JOHN, ROBERT H.
Real-time simulation for Space Station p 7 A87-37250

ST-PIERRE, DANY
Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-46882

STAPF, E.
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2361-VOL-1] p 73 N87-27707

STAR, JEFFREY L.
Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817

STARK, J. A.
Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860879] p 42 A87-38760

STATLER, RICHARD L.
Testing of materials for solar power space applications p 107 A87-53946

STEDMAN, J. K.
Advanced fuel cell concepts for future NASA missions. p 99 N87-29830

STEELS, R.
Modal-survey testing of the Olympus spacecraft p 152 A87-42288

STEIN, J. W.
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

STEINBERG, A. L.
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station p 118 A87-33003
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724

STELLA, PAUL
Advanced photovoltaic solar array design assessment. p 80 N87-26429

STEPANTSOV, V. I.
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735

STEPHENS, MARK
SOT: A rapid prototype using TAE windows p 114 N87-23161

STERN, P. H.
Space station integrated wall design and penetration damage control
[NASA-CR-179166] p 39 N87-26581

STERN, S. A.
Inadequacy of single-impulse transfers for path constrained rendezvous p 90 A87-41615

STEVENS, CHRISTINE L.
Liquid propellant tank ullage bubble deformation and breakup in low gravity reorientation
[AIAA PAPER 87-2021] p 92 A87-45380

STEVENS, N. J.
Spacecraft environment interaction investigation
[AD-A179183] p 140 N87-23878

STEVENS, N. JOHN
Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0327] p 7 A87-41611

STEWART, W. F.
Magnetic refrigeration for space platforms
[SAE PAPER 861724] p 116 A87-32813

STIDHAM, CURT
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation p 131 N87-26168

STOCKWELL, ALAN E.
Interdisciplinary analysis procedures in the modeling and control of large space-based structures p 21 A87-42675

STOCKWELL, BRIAN
Commercialization of space - The insurance implications p 166 A87-32480

STOEWER, H.
Space 2000 in Europe p 156 A87-26024

STOKER, C. R.
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53002

STOKES, LEBARIAN
An electromechanical attenuator/actuator for Space Station docking p 139 N87-26679

STONE, DENNIS A.
Advanced technology for the Space Station p 120 A87-40983

STORNELLI, S.
Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25366

STOWE, LARRY
Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25580

STRAMLER, J. H.
A comparison between space suited and unsuited reach envelopes p 47 A87-33013

STROHBEHN, K.
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32236

STROHBEHN, KIM
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32736

STUART, GARY B.
Computer simulation of on-orbit manned maneuvering unit operations
[SAE PAPER 861783] p 47 A87-32632

STUCKEY, W. K.
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182601] p 110 N87-29709

STUDER, P.
Actuators for actively controlled space structures p 59 A87-42816

STUEBPEL, D.
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860936] p 42 A87-38725

SU, SHIN-YI
Orbital debris environment resulting from future activities in space p 136 A87-44362

SUDHAKAR, B.
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-29336

SUHOZA, J. P.
Evaluation of carbon-carbon for space engine nozzle p 98 N87-26116

SULLIVAN, JAMES D.
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23086

SULMEISTERS, TAL K.
NERVA derived nuclear orbit transfer system
[AIAA PAPER 87-2155] p 92 A87-45439

SUN, R.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

SUNDARARAJAN, N.
Robust controller synthesis for a large flexible space antenna p 64 A87-32235

SUNDBERG, GALE R.
Space Station 20-kHz power management and distribution system p 75 A87-38613

SUTTER, THOMAS R.
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731

SUZUKI, M.
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443

SUZUKI, YOSHIAKI
Communication missions for geostationary platforms p 84 A87-34797

SWENSON, G. R.
Spacecraft ram glow and surface temperature p 10 N87-26205

SWITZER, COLLEEN A.
Coaxial tube array space transmission line characterization
[NASA-TM-88864] p 86 N87-22933

SYKES, GEORGE F.
Assessment of space environment induced microdamage in toughened composite materials p 20 A87-38858

SZCZUR, MARTHA
TAE Plus: A conceptual view of TAE in the space station era p 9 N87-23157

SZCZUR, MARTHA R.
Standards for the user interface - Developing a user consensus
[AIAA PAPER 87-2208] p 169 A87-48524

T

TABATA, MASAKI
Modal study of simplex masts p 144 A87-32339

TACINA, R. R.
Conceptual design and integration of a Space Station resistojet propulsion assembly
[AIAA PAPER 87-1860] p 91 A87-46258

TACINA, ROBERT R.
Conceptual design and integration of a space station resistojet propulsion assembly
[NASA-TM-88947] p 93 N87-20376
Space station propulsion system technology
[NASA-TM-100108] p 97 N87-25422

TAKAHARA, KENICHI
The design and development of a two-dimensional adaptive truss structure p 40 N87-29880

TAKAHASHI, MASAMI
Japanese experiment module data management and communication system p 147 A87-32542

TAKAHASHI, TOSHIAKI
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLFF method p 144 A87-32334

TAKAMATSU, KIYOSHI
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0888] p 14 A87-33632

TAKIKAWA, KUNIKO
Autonomous decentralized system concept for Space Station p 146 A87-32541

TAMAOKI, HIDEHIKO
A consideration to vibration control for a large space structures p 54 A87-32441

TAMBURINI, F.
The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860936] p 42 A87-38725

TAMMA, KUMAR K.
Reduced modeling and analysis of large repetitive space structures via continuum/discrete concepts p 15 A87-35327

TANABE, TORU
System and operation analyses of OTV Network - A new space transportation concept p 145 A87-32475

TANAKA, JUNZO
Development of exposed deck of Japanese experiment module p 145 A87-32532

TANAKA, KIYOSHI
Development of fluid loop system for spacecraft p 144 A87-32370

TANAKA, T.
Japanese data relay satellite system
[AIAA PAPER 87-2185] p 154 A87-48585

TANAKA, TOSHIYUKI
Autonomous decentralized system concept for Space Station p 146 A87-32541

TANZER, H. J.
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32666

TAPPE, W.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-26405

TAYLOR, L. W.
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure
[AIAA PAPER 87-0885] p 16 A87-33656

TAYLOR, L. W., JR.
Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50506

TAYLOR, ROBERT L.
An integrated, optimization-based approach to the design and control of large space structures
[AD-A179458] p 34 N87-23083

TAYLOR, ROY A.
A space debris simulation facility for spacecraft materials evaluation p 11 A87-32256

TEFFT, E. C., III
Enhanced evaporative surface for two-phase mounting plates
[SAE PAPER 860879] p 42 A87-38760

TEGART, JAMES
Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21156

TENNEY, DARREL R.
Composite tubes for the Space Station truss structure p 20 A87-38851

TEREN, FRED
Space station electric power system requirements and design
[NASA-TM-88890] p 88 N87-22931

TERUI, F.
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2346] p 60 A87-50413

TERWILLIGER, R.
SAGA: A project to automate the management of software production systems
[NASA-CR-180276] p 10 N87-27412

TEZUKA, HITOSHI
Development of exposed deck of Japanese experiment module p 145 A87-32532

THIEME, G.
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2361-VOL-1] p 73 N87-27707
Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2361-VOL-4] p 73 N87-27709

THOMIN, G.
Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29888

THOMPSON, DANIEL F.
Microcrack resistant structural composite tubes for space applications p 108 A87-41022

THOMPSON, JOE J.
Space Station EVA using a maneuvering enclosure unit
[SAE PAPER 861010] p 135 A87-38782

THOMPSON, JOSEPH J.
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780

THOMPSON, R. C.
A quasi-analytical method for non-iterative computation of nonlinear controls p 68 N87-22731

THOMPSON, WILLIAM B.
Electrodynamic tether propulsion - Potential uses and open issues p 124 A87-40510

THORESON, D. W.
Environmental avoidance concepts for steerable Space Station radiators
[SAE PAPER 861031] p 41 A87-32885

THORNTON, WILLIAM E.
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38784

THORSTENSON, YVONNE R.
Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27362

THURMOND, BEVERLY A.
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720

TILLMAN, BARRY
Human factors standards for space habitation
p 162 A87-33522

TINKER, M. L.
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180568] p 29 N87-20569

TISHLER, V. A.
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735

TIZZI, S.
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327

TOBBE, PATRICK A.
Contact dynamics math model
[NASA-CR-178147] p 71 N87-25801

TODA, Y.
Study of actuator for large space manipulator arm
p 12 A87-32545
A master-slave manipulator system for space use
p 147 A87-32546

TODA, YOSHITERU
Development of harmonic drive actuator for space manipulator p 149 A87-35076

TODA, YOSHITSUGU
Development of a small-sized space manipulator
p 101 A87-51879

TOLIVAR, A. F.
Control technology overview in CSI
p 69 N87-24507

TOLK, N. H.
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-29181

TOMITA, MASAYUKI
Structure and function of Deployable Truss Beam (DTB) p 12 A87-32548

TORRE, LARRY P.
Structure-property relationships in polymer resistance to atomic oxygen p 109 A87-38942
Comments on the interaction of materials with atomic oxygen p 110 N87-29206

TOTI, WILLIAM J.
The effect of multipath on digital communications systems: With application to space station
[AD-A178078] p 86 N87-23979

TOWNSEND, JOHN S.
Space station structures and dynamics test program
[NASA-TP-2710] p 29 N87-20569
Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22728
Space station structures and dynamics test program
p 33 N87-22751

TRABANINO, RUDY
Space Station galley design
[SAE PAPER 860932] p 119 A87-38722

TRIPPI, A.
Status of the RITA - Experiment on EURECA
[AIAA PAPER 87-2068] p 123 A87-39002

TRIVEDI, DINESH J.
An experimental study of transient waves in a plane grid structure
[AIAA PAPER 87-0943] p 18 A87-33741

TRZCINSKI, E.
Mass spectrometers and atomic oxygen
p 141 N87-29176

TSANG, CHIT-SANG
FDMA system design and analysis for Space Station
p 85 A87-45483

TSUCHIYA, KAZUO
Precise pointing control of flexible spacecraft
p 55 A87-32448

TSUDA, SHOICHI
Payload boomerang technology for space experiments at very low gravity level p 146 A87-32540

TU, K.
Antenna systems and RF coverage for the Space Station p 2 A87-45523

TUELL, L. P.
Equations of motion of a space station with emphasis on the effects of the gravity gradient
[NASA-TM-89098] p 64 N87-21093

TULLIS, THOMAS S.
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 118 A87-33003
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-38724

TURINETTI, G.
Organic Rankine cycle power conversion systems for space applications p 156 N87-29889

TURNER, GARY F.
Test results from the solar array flight experiment
p 83 N87-29010

TURNER, J. D.
A quasi-analytical method for non-iterative computation of nonlinear controls p 68 N87-22731

TURNER, JAMES D.
Research in slewing and tracking control
p 70 N87-24512

TURNER, RUSSELL B.
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739

U

UENO, KENJI
On-board K- and S-band multi-beam antennas
p 86 A87-46281

UNTERBERG, WALTER
Density uncertainty effect on cost of space station reboost p 170 N87-20887

V

VAICAITIS, R.
Vibrations and structureborne noise in space station
[NASA-CR-181391] p 39 N87-29580

VALENTINY, G.
Servicing of the polar platform p 138 N87-20829

VALLERANI, ERNESTO
Columbus pressurized modules p 153 A87-46845

VAMPOLA, A. L.
Thick dielectric charging on high altitude spacecraft
p 87 N87-25891

VAN SCHOOR, MARTHINUS C.
Material damping in aluminum and metal matrix composites p 108 A87-48797

VANDERVOORT, R. J.
Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22748

VANDEVENNE, JEROEN
Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2318] p 79 N87-24535

VANE, DEBORAH
Earth resources instrumentation for the Space Station Polar Platform p 120 A87-44184

VANKE, V. A.
Shape control of the directional pattern in a microwave-beam power transmission channel
p 148 A87-34345
The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35799

VANSWIETEN, AAD
End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC)
[FOK-TR-R-86-091-VOL-2] p 102 N87-24486
End effector development study, volume 1
[FOK-TR-R-86-091-VOL-1] p 102 N87-25336
End effector development study. Volume 3: Appendices
[FOK-TR-R-86-091-VOL-3] p 102 N87-25337

VASILEVSKAIA, E. G.
Legal problems concerning manned space flight
p 151 A87-43339

VAUGHAN, ROBERT E.
End-to-end communications for Space Station
p 85 A87-45522

VEDRENNE, G.
The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-36443

VENDITTI, F.
Automatic docking maneuver and attitude control a vision p 71 N87-25385

VENKAYYA, V. B.
Structural optimization with frequency constraints
[AIAA PAPER 87-0767] p 13 A87-33589
Structural and control optimization of space structures
[AIAA PAPER 87-0939] p 17 A87-33737

VENNERI, SAMUEL L.
Future trends in spacecraft design and qualification
p 2 N87-27056

VERDIN, D.
Surface modification to minimize the electrostatic charging of Kapton in the space environment
p 87 N87-25893

VERESHCHETIN, V. S.
Legal problems concerning manned space flight
p 151 A87-43339

VEROSTKO, CHARLES E.
Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 50 A87-38762

VETRELLA, S.
The Tethered Satellite System as a new remote sensing platform p 124 A87-39183

VISENTINE, J.
Selected materials issues associated with Space Station p 105 A87-32891
Review of Low Earth Orbital (LEO) flight experiments
p 131 N87-29174

VISENTINE, J. T.
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103
Mass spectrometers and atomic oxygen
p 141 N87-29176

VISENTINE, JAMES
High intensity 5 eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-29188

VISENTINE, JAMES T.
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements
p 109 N87-29175

VISWANATHAN, R.
Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41611

VOIGT, SUSAN J.
A workstation environment for software engineering
p 116 N87-29128
Engineering graphics and image processing at Langley Research Center p 10 N87-29129

VOITKOV, B. I.
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-48121

VON FLOTOW, A. H.
Some approximations for the dynamics of spacecraft tethers
[AIAA PAPER 87-0821] p 122 A87-33697
Wave propagation in periodic truss structures
[AIAA PAPER 87-0944] p 18 A87-33742

VON KRIES, WULF
Flunking on Space Station cooperation?
p 150 A87-37884

VONPRAGENAU, GEORGE L.
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems
p 8 N87-22716

VOSSA, H. L.
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 38 N87-26058

VU, LOC QUOC
Dynamics of flexible structures performing large overall motions: A geometrically-nonlinear approach
p 84 N87-21335

W

WADA, B. K.
Validation of large space structures by ground tests
p 11 A87-32326
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33675
Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-20561
Structural dynamics system model reduction
p 32 N87-22727
WADA, BEN K.
On sine dwell or broadband methods for modal testing
[AIAA PAPER 87-0861] p 16 A87-33752
Structural qualification of large spacecraft
p 29 N87-20291
Verification of flexible structures by ground test
p 31 N87-22713
Ground test of large flexible structures
p 34 N87-24013
WADE, D. C.
The mechanics of manufacturing in space
p 107 A87-40386
WAGNER, LEE
Space station power semiconductor package
[NASA-CR-180829] p 91 N87-28625
WAGNER, R.
Carbon fibre slotted waveguide arrays
p 66 A87-41302
WAGNER, R. C.
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-26712
WAGENER, R. G.
Power management equipment for space applications
[SAE PAPER 861621] p 74 A87-32575
WAHBAH, M. M.
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50062
WAITES, HENRY
Large space structures testing
[NASA-TM-100300] p 36 N87-24520
Distributed control using linear momentum exchange devices
[NASA-TM-100306] p 75 N87-24521
WAITES, HENRY B.
Large space structures ground experiment checkout
p 30 N87-22704
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-89004] p 75 N87-24723
WAKARI, T.
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48802
WALKER, B. K.
Mass property estimation for control of asymmetrical satellites p 63 A87-52098
WALKER, BRUCE K.
On the performance analysis of a real-time distributed computer system p 111 A87-31518
WALKER, DELORES H.
Testing of materials for solar power space applications p 107 A87-52348
WALKER, P.
Application of reanalysis techniques in dynamic analysis of spacecraft structures p 21 A87-50824
WALL, J. A.
Spacecraft dielectric material properties and spacecraft charging p 105 A87-33100
WALLGREN, KENNETH
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89293] p 116 N87-29124
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89294] p 116 N87-29144
WALLSTEN, RICHARD E.
Mobile remote manipulator vehicle system
[NASA-CASE-LAR-13393-1] p 100 N87-29116
WALSH, DONALD E.
Present and future military uses of outer space: International law, politics, and the practice of states
[AD-A178722] p 170 N87-21763
WALSH, JOANNE L.
Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0826] p 14 A87-33613
WALTER, L. B.
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-89221] p 137 N87-25339
WANG, J.
The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42585
WARD, BENJAMIN A.
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A178711] p 72 N87-25805
WARD, M. T.
Integrated scheduling and resource management
[AIAA PAPER 87-2213] p 116 A87-48837
WARD, ROBERT M., JR.
End-to-end communications for Space Station
p 85 A87-43522
WARDEN, ROBERT M.
Folding, articulated, square truss p 45 N87-29858
WARNAAR, DIRK B.
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33736
WARTENBERG, H.
The evolution of a serviceable EURECA
[MBB-UR-E-923/86] p 121 N87-26641
WASEL, ROBERT A.
An overview of photovoltaic applications in space
p 90 N87-26414
WATANABE, S. F.
Fiber-optic monitors for space structures
p 11 A87-31505
WEBBON, BRUCE W.
An evaluation of options to satisfy Space Station EVA requirements
[SAE PAPER 861008] p 134 A87-38780
WEBER, W. J., III
Antenna Technology Shuttle Experiment (ATSE)
p 67 N87-24939
WEI, J. D.
Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47912
WEISEL, MARK
Physiological requirements and pressure control of a spacestation
[SAE PAPER 860963] p 150 A87-38747
WEISSHAUPT, U.
Micrometeorite exposure of solar arrays
p 92 N87-28662
WELCH, RAYMOND V.
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 56 A87-32738
WELCHER, BLAKE A.
Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 139 N87-20303
WENSTRAN, H. L.
The Preferred Modular Opto-electronic Multispectral Scanner (P-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-875/86] p 130 N87-25829
WESSELSKI, CLARENCE J.
Collect lock joint for space station truss
[NASA-CASE-MSC-21207-1] p 39 N87-25079
WESTBROOK, JACK H.
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WEYANDT, J.
The evolution of a serviceable EURECA
[MBB-UR-E-923/86] p 121 N87-26641
WHITE, K. ALAN, III
Liquid droplet radiator development status
[AIAA PAPER 87-1537] p 43 A87-43099
Liquid droplet radiator development status
[NASA-TM-89852] p 44 N87-20393
WHITE, K. ALLAN, III
Liquid sheet radiator
[AIAA PAPER 87-1525] p 43 A87-43046
WHITEHEAD, R. D.
Design parameters and environmental considerations for a reusable aeroassisted orbital transfer vehicle
[AIAA PAPER 87-1655] p 160 A87-43021
WHITELAW, V.
Space Station Information System integrated communications concept
[AIAA PAPER 87-2220] p 114 A87-48859
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2226] p 114 A87-48827
WHITELAW, VIRGINIA A.
Space Station data management system architecture
p 111 A87-37293
WHITMAN, RUTH
Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860973] p 134 A87-38755
WHITMORE, HENRY
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38794
WHITNEY, D. E.
An integrated approach to spacecraft design for robotic servicing
[AIAA PAPER 87-1672] p 100 A87-41152
WHITSETT, C. E.
Role of the manned maneuvering unit for the Space Station
[SAE PAPER 861634] p 133 A87-32867
WIDNALL, WILLIAM
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A178711] p 72 N87-25805
WIE, BONG
Active vibration control synthesis for the COFS-I - A classical approach
[AIAA PAPER 87-2322] p 23 A87-50443
A new concept of generalized structural filtering for active vibration control synthesis
[AIAA PAPER 87-2456] p 24 A87-50502
WIENSS, W.
Possibilities of the further development of Columbus to an autonomous European space station
[MBB-UR-E-922/86] p 158 N87-25418
WILKER, J. J.
Acoustic effects on the dynamic of lightweight structures p 28 N87-20272
WILEY, LOWELL F.
Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 860975] p 124 A87-38757
WILHELM, E. E.
Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-28582
WILHELM, JOHN A.
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180242] p 53 N87-27409
WILKERSON, C. L.
Space-based OTV tailoff disposition
[AIAA PAPER 87-1767] p 91 A87-45181
WILLIAMS, D. B.
Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-29867
WILLIAMS, J. L.
Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50508
WILLIAMS, J. P.
On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2458] p 61 A87-50505
WILLIAMS, JAMES H., JR.
Wave-mode coordinates and scattering matrices for wave propagation
[AD-A178858] p 29 N87-21030
Comparison of wave-mode coordinate and pulse summation methods
[AD-A177780] p 30 N87-21682
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 70 N87-22259
WILLIAMS, JEFFREY P.
Status report and preliminary results of the spacecraft control laboratory experiment p 69 N87-22717
Controls-structures-electromagnetics interaction program p 69 N87-24002
Slew maneuvers on the SCOLE Laboratory Facility
p 69 N87-24011
WILLIAMS, TREVOR
Identification of large space structures - A factorization approach p 25 A87-52959
WILLIAMSON, W. S.
Automatic charge control system for geosynchronous satellites p 87 N87-26899
WILLSHIRE, KELLI F.
Space Station end effector strategy study
[NASA-TM-100480] p 103 N87-29583
WILSON, ANDREW
Ion thrusters advance p 83 A87-34188
WILSON, GERALD R.
Military space station implications
[AD-A160801] p 172 N87-28664
WILSON, J. F.
Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22739

WILSON, JOHN F.
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49615
WILTBERGER, NANCY L.
The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325
WINCHELL, J. W.
Commercial US transfer vehicle overview
[SAE PAPER 861764] p 1 A87-32625
WISE, JOSEPH
High power/large area PV systems
p 80 N87-26452
WITTCHEN, T.
Absolute indoor calibration of large area solar cells
p 159 N87-29015
WOHLWEND, J. W.
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1540] p 44 A87-44843
WOLBERS, HARRY L., JR.
Habitation module for the Space Station
[SAE PAPER 860928] p 163 A87-38716
WOLF, P.
ESA Columbus polar platform design concept
p 156 N87-20627
WOLFE, M. G.
Trends in space transportation p 168 A87-41572
WOLFF, F.
Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88928] p 68 N87-23880
WOLFF, FREDRICK J.
20 kHz Space Station power system
p 76 A87-40378
WOO, H. H.
Preliminary evaluation of a reaction control system for the space station p 67 N87-22736
WOO, K. T.
GPS applications to the Space Station
p 136 A87-45525
WOOD, GEORGE M., JR.
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
WOOD, L. L.
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-008487] p 171 N87-22697
WOODS, T. G.
Advanced EVA system design requirements study: EVAS/space station system interface requirements
[NASA-CR-171991] p 120 N87-20351
WOOLFORD, BARBARA J.
Manned space flight p 167 A87-33019
WORLEY, H. EUGENE
Large space structures testing
[NASA-TM-100308] p 35 N87-24520
WRIGHT, M. A.
Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-28581
WRIGHT, ROBERT L.
NASA/DOD Control/Structures Interaction Technology, 1986
[NASA-CP-2447-PT-2] p 34 N87-24486
WU, S. T.
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-181166] p 141 N87-28082
WYDEVEN, T.
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860986] p 50 A87-38764
WYDEVEN, THEODORE
Reactions of atomic oxygen (O(P-3)) with polybutadienes and related polymers p 109 N87-261[illegible]7
WYN-ROBERTS, D. W.
A microgravity isolation mount p 161 N87-29861
WYNVEEN, R. A.
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860994] p 51 A87-38771

Y

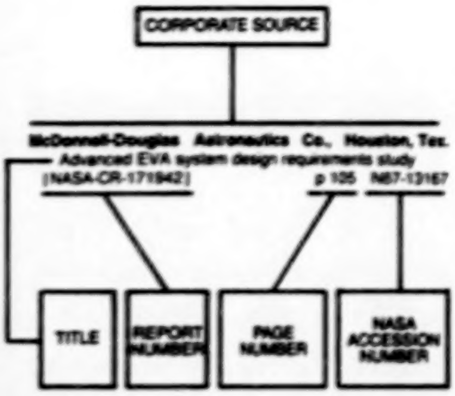
YAE, K. H.
Response bounds for linear underdamped systems
[ASME PAPER 87-APM-34] p 59 A87-42506
YAJIMA, NOBUYUKI
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel
p 55 A87-32446
A study on singularity of single gimbal CMG systems
p 149 A87-35077
Modeling and control of torsional vibrations in a flexible structure p 60 A87-50033
YAKUT, M. M.
Space Station galley design
[SAE PAPER 860932] p 119 A87-38722
YAM, YEUNG
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-46301
YAMADA, AKIRA
Water recycling system using thermopervaporation method p 46 A87-32458
YAMADA, KATSUHIKO
Precise pointing control of flexible spacecraft
p 55 A87-32445
Development of a small-sized space manipulator
p 101 A87-51979
YAMAGATA, TASUKU
Development of graphite epoxy space structure
p 105 A87-32342
YAMAGUCHI, ISAO
Local control for large space structures
p 54 A87-32440
A preliminary study on a linear inertial actuator for LSS control p 56 A87-32447
YAMAGUCHI, MASANOBU
Development of graphite epoxy space structure
p 105 A87-32342
YAMAMOTO, HARUMITSU
Japanese experiment module data management and communication system p 147 A87-32542
YAMAMOTO, MASATAKA
Structural design and component tests of large geostationary satellite bus p 144 A87-32335
YAMAMOTO, TETSUYA
Development of full scale deployable CFRP truss for space structure p 25 A87-51780
YAMANAKA, TATSUO
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32530
YANG, CHANG-DONG
New time-domain identification technique
p 58 A87-40889
YEH, FANG-BO
New time-domain identification technique
p 58 A87-40889
YEH, TSO-PING
Analytical and experimental modeling of zero/low gravity fluid behavior
[AIAA PAPER 87-1865] p 91 A87-45280
YEREMIN, A. V.
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20736
YERBACK, LARRY P.
The Space Station - Work Package 3
p 118 A87-32529
YEUNG, HUBERT K.
Wave-mode coordinates and scattering matrices for wave propagation
[AD-A176999] p 29 N87-21030
Comparison of wave-mode coordinate and pulse summation methods
[AD-A177798] p 30 N87-21082
YONEMOTO, JAMES T.
Space Station tracking subsystem sensor evaluation
p 85 A87-45520
YORCHAK, JOHN P.
Planning for unanticipated satellite servicing teleoperations p 119 A87-33048
YOSHIDA, T.
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-38529
YOSHIHARA, MAKOTO
The design and development of a two-dimensional adaptive truss structure p 40 N87-28880
YOSHIKADO, SHIN
Observation of precipitation from space by the weather radar p 146 A87-32507
YOSHIMOTO, SHIGETOSHI
Communication missions for geostationary platforms
p 84 A87-34797
YOSHIMURA, SHOICHI
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32530
YOSHIMURA, YOSHINORI
Development of exposed deck of Japanese experiment module p 145 A87-32532
YOSHIOKA, T.
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-48802
YOUNG, ARCHIE C.
Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms
[AAS PAPER 86-041] p 133 A87-32743
YOUNG, CHRIS
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29583
YOUNG, JOHN W.
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731
Dual keel space station control/structures interaction study p 67 N87-22737
YOUNG, LEIGHTON E.
Solar array flight experiment/dynamic augmentation experiment
[NASA-TP-2690] p 63 N87-20380
YOUNG, RICHARD C.
Proposed application of automated biomonitoring for rapid detection of toxic substances in water supplies for permanent space stations p 164 A87-40098
YU, T. L.
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132
YURKOVICH, S.
Control of multiple-mirror/flexible-structures in slew maneuvers
[AIAA PAPER 87-2324] p 24 A87-50445

Z

ZAHN, R. W.
An advanced wind scatterometer for the Columbus Polar Platform payload p 155 A87-53117
ZAITSEV, YURIY
IKI department head on orbital power plants
p 158 N87-27093
ZAK, M.
Modeling of controlled flexible structures with impulsive loads p 33 N87-22745
ZAK, MICHAIL
Dynamical response to pulse excitations in large space structures
[AIAA PAPER 87-0710] p 15 A87-33656
ZANA, LYNETTE M.
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 92 A87-52252
ZDANKIEWICZ, ED M.
Phase change water recovery for Space Station - Parametric testing and analysis
[SAE PAPER 860985] p 51 A87-38765
ZENTNER, RONALD C.
Prototype thermal bus for manned Space Station compartments
[SAE PAPER 861025] p 41 A87-38888
ZEWEN, HELMUT
Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-162] p 90 A87-42880
ZHUKOV, G. P.
Legal problems concerning manned space flight
p 151 A87-40339
ZIJDEMANS, PH. J.
The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-28875
ZIMCIK, D. G.
Effect of long-term exposure to LEO space environment on spacecraft materials p 109 A87-38428
Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-28207
ZIMM, C. B.
Magnetic refrigeration for space platforms
[SAE PAPER 861734] p 116 A87-32613
ZIMMERMAN, D. C.
Vibration suppression using a constrained rate-feedback Threshold control strategy
[AIAA PAPER 87-0741] p 8 A87-33688
ZULIANI, L.
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration
p 83 N87-28886
ZWANENBURG, R.
The Fokker Strongback solar array p 82 N87-28879

CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing


CORPORATE SOURCE
McDonnell-Douglas Astronautics Co., Houston, Tex.
Advanced EVA system design requirements study
[NASA-CR-171942] p 105 N87-13167
TITLE
REPORT NUMBER
PAGE NUMBER
NASA ACCESSION NUMBER

Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A175529] p 26 N87-20355
The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26907

AEC-Able Engineering Co., Inc., Goleta, Calif.
Folding, articulated, square truss p 40 N87-29859
Space Station alpha joint bearing p 83 N87-29862

AEG-Telefunken, Wedel (West Germany).
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits
p 156 N87-29868
Improved solar generator technology for the EURECA low Earth orbit p 159 N87-29874
High power solar array technologies
p 82 N87-29876

Aeritalia S.p.A., Naples (Italy).
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulator, volume 2
[LP-RP-AI-204-VOL-2] p 69 N87-24480
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24481
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Docking-undocking phase analysis
[LP-RP-AI-204-VOL-1] p 70 N87-24514

Aerojet Strategic Propulsion Co., Sacramento, Calif.
Evaluation of carbon-carbon for space engine nozzle
p 59 N87-28116

Aerospace Corp., El Segundo, Calif.
Potential modulations on SCATHA (Spacecraft Charging At High Altitude) spacecraft
[AD-A178815] p 140 N87-21024
Laboratory studies of atomic oxygen reactions with solids p 4 N87-26185
Effects on advanced materials: Results of the STS-8 EOIM (Effects of Oxygen Interaction with Materials) experiment
[AD-A182931] p 110 N87-29706

Aerospace Corp., Los Angeles, Calif.
Potential modulation on the SCATHA spacecraft
p 138 A87-34480
Thick dielectric charging on high altitude spacecraft
p 27 N87-26861

Air Command and Staff Coll., Maxwell AFB, Ala.
Military man in space: A history of Air Force efforts to find a manned space mission
[AD-A178873] p 171 N87-25815

Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
Development of precision structural joints for large space structures p 28 N87-20374

Air Force Geophysics Lab., Hanscom AFB, Mass.
Automatic charge control system for geosynchronous satellites p 87 N87-26860

Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
Present and future military uses of outer space: international law, politics, and the practice of states
[AD-A176722] p 170 N87-21753
Optimal shuttle attitude changes using tethers
[AD-A178206] p 129 N87-22758
Moving-bank multiple model adaptive estimation applied to flexible spacestructure control
[AD-A178870] p 69 N87-22761
Developing a voice-controlled, computer-generated display to assist space station astronauts during maintenance activity
[AD-A178897] p 120 N87-22762
A quantitative comparison of several orbital maneuvering vehicle configurations for satellite repair/replenishment
[AD-A179108] p 161 N87-23877
A systems analysis of emergency escape and recovery systems for the US space station
[AD-A178230] p 3 N87-23880
An analysis of space station motion subject to the parametric excitation of periodic elevator motion
[AD-A178235] p 68 N87-23881
A multiple attribute decision analysis of manned airlock systems
[AD-A178241] p 137 N87-23882
The effects of structural perturbations on decoupled control p 35 N87-25359
Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code
[AD-A182589] p 81 N87-29188
The liquid droplet radiator in space: A parametric approach
[AD-A182835] p 46 N87-29217

Air Force Office of Scientific Research, Bolling AFB, Washington, D.C.
Air Force basic research in dynamics and control of large space structures p 53 N87-20577

Air Force Rocket Propulsion Lab., Edwards AFB, Calif.
Identification of large space structures: A state-of-practice report p 31 N87-22705

Air Force Space Div., Los Angeles, Calif.
National space transportation studies
[SAE PAPER 861681] p 160 A87-32580

Air Force Weapons Lab., Kirtland AFB, N. Mex.
Joint Optics Structures Experiment (JOSE)
p 34 N87-24487

Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
Optimum mix of passive and active control of space structures p 65 N87-22714

AiResearch Mfg. Co., Torrance, Calif.
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs
[SAE PAPER 860987] p 51 A87-38768

Akron Univ., Ohio.
Effect of nozzle geometry on the resistojet exhaust plume
[AIAA PAPER 87-2121] p 62 A87-52252

Alabama Univ., Huntsville.
Potential modulation on the SCATHA spacecraft
p 138 A87-34480
Investigation of beam-plasma interactions
[NASA-CR-180579] p 129 N87-22508
Analytical determination of space station response to crew motion and design of suspension system for microgravity experiments p 67 N87-22752
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-181165] p 141 N87-28082
Interaction of hyperthermal atoms on surfaces in orbit: The University of Alabama experiment
p 109 N87-29177
Electron beam experiments at high altitudes
p 142 N87-29946

Alcatel Thomson Espace, Toulouse (France).
Assessment of space station power system
[ATES-AN-85/486] p 79 N87-24530

Allegheny Observatory, Pittsburgh, Pa.
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

Allied Bendix Aerospace, Teterboro, N.J.
Adaptive momentum management for large space structures
[NASA-CR-178086] p 67 N87-22759

Arizona State Univ., Tempe.
A hybrid nonlinear programming method for design optimization p 7 A87-35718

Arizona Univ., Tucson.
Astrometric telescope of ten microarcsecond accuracy on the Space Station p 122 A87-35222

Army Military Personnel Center, Alexandria, Va.
Thermal and dynamical effects on electrodynamic space tethers
[AD-A180276] p 130 N87-25351
Suboptimal control of large flexible space structures experiencing rotational dynamics nonlinearities
[AD-A180838] p 71 N87-25352

Army War Coll., Carlisle Barracks, Pa.
Military space station implications
[AD-A180821] p 172 N87-26884

Astro Aerospace Corp., Carpinteria, Calif.
Structural concepts for large solar concentrators
[NASA-CR-4075] p 85 N87-21094
Design, development and fabrication of a deployable/retractable truss beam model for large space structures application
[NASA-CR-178287] p 35 N87-25349

Atomic Energy Research Establishment, Harwell (England).
Surface modification to minimize the electrostatic charging of Kapton in the space environment
p 87 N87-26868

Auburn Univ., Ala.
Analytical solutions for static elastic deformations of wire ropes
[AIAA PAPER 87-0720] p 6 A87-32981
Initial investigations into the damping characteristics of wire rope vibration isolators
[NASA-CR-180080] p 26 N87-20589
Space Station/Shuttle Orbiter dynamics during docking p 66 N87-22708
Improving stability margins in discrete-time LQG controllers p 31 N87-22719
A new approach for vibration control in large space structures p 33 N87-22742

B

Babcock and Wilcox Co., Lynchburg, Va.
Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

Ball Aerospace Systems Div., Boulder, Colo.
Rendezvous and docking tracker
[AAS PAPER 86-014] p 123 A87-32730

Phase 3 study of selected tether applications in space. Volume 1: Executive summary
[NASA-CR-179185] p 131 N87-29585

Battelle Pacific Northwest Labs., Richland, Wash.

Two-phase reduced gravity experiments for a space reactor design p 8 N87-21154

Beech Aircraft Corp., Boulder, Colo.

Space station experiment definition: Long term cryogenic fluid storage p 94 N87-21144

Space station experiment definition: Long-term cryogenic fluid storage
[NASA-CR-4072] p 97 N87-24641

Belgian Royal Observatory, Brussels.

Solid Earth panel report p 157 N87-20838

Bell Telephone Labs., Inc., Murray Hill, N. J.

A crisis in the NASA space and earth sciences programme p 112 A87-37988

Bend Research, Inc., Oreg.

A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 880994] p 50 A87-38763

Bendix Corp., Teterboro, N.J.

Adaptive momentum management for the dual keel Space Station
[AIAA PAPER 87-2586] p 62 A87-50558

Bionetics Corp., Hampton, Va.

An advanced technology space station for the year 2025, study and concepts
[NASA-CR-178208] p 120 N87-20040

Boeing Aerospace Co., Houston, Tex.

Results on reuse of reclaimed shower water
[SAE PAPER 880983] p 50 A87-38762

Boeing Aerospace Co., Kent, Wash.

Mixing-induced fluid destratification and ullage condensation p 95 N87-21149

Space station propulsion-ECLSS interaction study
[NASA-CR-175093] p 54 N87-29584

Boeing Aerospace Co., Seattle, Wash.

National space transportation studies
[SAE PAPER 861681] p 160 A87-32588

Prototype thermal bus for manned Space Station compartments
[SAE PAPER 861825] p 41 A87-32888

Nonlinear transient analysis of joint dominated structures
[AIAA PAPER 87-0892] p 17 A87-33709

Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 880953] p 164 A87-38740

Plant and animal accommodation for Space Station Laboratory
[SAE PAPER 880975] p 124 A87-38757

Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1628] p 44 A87-43126

Space-based OTV boiloff disposition
[AIAA PAPER 87-1767] p 91 A87-45181

Overview: Fluid acquisition and transfer p 94 N87-21146

Flexible spacecraft simulator p 31 N87-22718

Precision pointing and control of flexible spacecraft p 66 N87-22723

Dynamics of trusses having nonlinear joints p 32 N87-22724

Equivalent beam modeling using numerical reduction techniques p 32 N87-22725

High speed simulation of flexible multibody dynamics p 33 N87-22738

Experimental characterization of deployable trusses and joints p 33 N87-22748

Comments on the interaction of materials with atomic oxygen p 110 N87-26208

Space station integrated wall design and penetration damage control
[NASA-CR-179165] p 39 N87-28581

Space station integrated wall design and penetration damage control. Task 3: Theoretical analysis of penetration mechanics
[NASA-CR-179166] p 39 N87-28582

Space station integrated wall design and penetration damage control. Task 4: Impact detection/location system
[NASA-CR-179167] p 4 N87-28583

Booz-Allen and Hamilton, Inc., Washington, D. C.

The impact of integrated water management on the Space Station propulsion system
[AIAA PAPER 87-1884] p 91 A87-45250

British Aerospace Public Ltd. Co., Stevenage (England).

Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20389

British Columbia Univ., Vancouver.

A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 35 N87-25357

Brookhaven National Lab., Upton, N. Y.

Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 99 N87-29405

Brunel Univ., Uxbridge (England).

Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2330] p 158 N87-27698

C

California Inst. of Tech., Pasadena.

Identification of the zero-g shape of a space beam
[AIAA PAPER 87-0872] p 15 A87-33836

Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711

Vibration suppression by stiffness control p 66 N87-22730

An experimental investigation of vibration suppression in large space structures using positive position feedback p 39 N87-29607

California State Univ., Northridge.

Soviet space stations as analogs, second edition
[NASA-CR-180920] p 157 N87-21898

California Univ., Berkeley.

Radiation environments and absorbed dose estimations on manned space missions p 139 A87-40028

Dynamics of flexible structures performing large overall motions: A geometrically-nonlinear approach p 64 N87-21336

An integrated, optimization-based approach to the design and control of large space structures
[AD-A179450] p 34 N87-23083

California Univ., Los Angeles.

Integrated control/structure design and robustness
[SAE PAPER 861821] p 6 A87-32857

Control augmented structural synthesis with transient response constraints
[AIAA PAPER 87-0749] p 56 A87-33573

Perturbation analysis of internal balancing for lightly damped mechanical systems with gyroscopic and circulatory forces p 22 A87-47812

Integrated control/structure design and robustness p 65 N87-22080

California Univ., Santa Barbara.

Remote Sensing Information Sciences Research Group: Santa Barbara Information Sciences Research Group, year 4
[NASA-CR-181073] p 115 N87-24817

Carnegie Inst. of Tech., Pittsburgh, Pa.

Response of joint dominated space structures
[NASA-CR-181202] p 37 N87-26387

Carnegie-Mellon Univ., Pittsburgh, Pa.

Response of joint dominated space structures
[NASA-CR-180664] p 36 N87-26571

Case Western Reserve Univ., Cleveland, Ohio.

Oxygen interaction with space-power materials
[NASA-CR-181288] p 132 N87-28633

Catholic Univ. of America, Washington, D.C.

Actuators for actively controlled space structures p 59 A87-42816

Control of robot manipulator compliance p 100 A87-45787

Modified independent modal space control method for active control of flexible systems
[NASA-CR-181088] p 34 N87-23880

A comparison between IMSC, PI and MIMSC methods in controlling the vibration of flexible systems
[NASA-CR-181188] p 38 N87-25805

Effect of bonding on the performance of a piezoactuator-based active control system
[NASA-CR-181414] p 74 N87-29713

Optimum shape control of flexible beams by piezo-electric actuators
[NASA-CR-181413] p 40 N87-29886

Centre d'Etudes et de Recherches, Toulouse (France).

On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit p 158 N87-26953

MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-26960

Centre National d'Etudes Spatiales, Toulouse (France).

Low frequency vibration testing on satellites p 27 N87-20384

Remote sensing applications: Commercial issues and opportunities for space station p 159 N87-20828

The high performance solar array GSR3 p 81 N87-26972

Centro Informazioni Studi Esperienze, Milan (Italy).

Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration p 83 N87-26965

Chamberlain Mfg. Corp., Waterloo, Iowa.

Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 880995] p 50 A87-38764

Chicago Univ., Ill.

Dynamics of atom-surface interactions p 141 N87-26183

City Univ. of New York, Bronx.

Development of a computer program to generate typical measurement values for various systems on a space station p 115 N87-29898

Colorado Univ., Boulder.

Evaluation of constraint stabilization procedures for multibody dynamical systems
[AIAA PAPER 87-0927] p 7 A87-33728

Inadequacy of single-impulse transfers for path constrained rendezvous p 80 A87-41615

Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53032

The growth and harvesting of algae in a micro-gravity environment p 165 N87-20325

Simulation of on-orbit satellite fragmentations p 140 N87-24515

A method of variable spacing for controlled plant growth systems in spaceflight and terrestrial agriculture applications
[NASA-CR-177447] p 130 N87-25767

Columbia Univ., New York, N.Y.

Vibrations and structureborne noise in space station
[NASA-CR-181381] p 39 N87-29580

Committee on Appropriations (U.S. House).

Department of Housing and Urban Development-independent agencies appropriations for 1988
[GPO-73-418] p 171 N87-22560

Committee on Appropriations (U.S. Senate).

National Aeronautics and Space Administration p 172 N87-30220

Committee on Commerce, Science, and Transportation (U.S. Senate).

National Aeronautics and Space Administration Authorization Act
[S-REPT-100-87] p 171 N87-24240

NASA authorization: Authorization of appropriations for the National Aeronautics and Space Administration for fiscal year 1988
[GPO-73-848] p 172 N87-30221

Committee on Science, Space and Technology (U.S. House).

National Aeronautics and Space Administration Authorization Act, fiscal year 1988
[H-REPT-100-204] p 171 N87-26024

Communications Research Centre, Ottawa (Ontario).

Effect of long-term exposure to Low Earth Orbit (LEO) space environment p 142 N87-26207

Consiglio Nazionale delle Ricerche, Rome (Italy).

Tethers in space: Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986 p 123 A87-30657

The Columbus program p 157 N87-29031

Control Dynamics Co., Huntsville, Ala.

One Controller at a Time (1-CAT): A mimo design methodology p 65 N87-22715

Contact dynamics math model
[NASA-CR-179147] p 71 N87-26601

Cornell Univ., Ithaca, N.Y.

A crisis in the NASA space and earth sciences programme p 112 A87-37988

D

Department of the Air Force, Washington, D.C.

Propellant tank resupply system
[AD-D012580] p 93 N87-20375

Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

Dynamic qualification of spacecraft by means of modal synthesis p 29 N87-20383

Modal-survey testing for system identification and dynamic qualification of spacecraft structures p 27 N87-27008

Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).

European utilization aspects studies p 158 N87-20824

Land panel report p 159 N87-20834

Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2331-VOL-1] p 73 N87-27709

Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2361-VOL-1] p 73 N87-27707

Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report
[ESA-CR(P)-2361-VOL-2] p 73 N87-27708

Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2361-VOL-4] p 73 N87-27709

Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-64/85] p 35 N87-24516

Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2338] p 156 N87-27688

The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-29012

Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

Aeroassist flight experiment guidance, navigation and control
[AAS PAPER 86-042] p 133 A87-32744

Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295

Draper (Charles Stark) Lab., Inc., Houston, Tex.

Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531

DYNACS Engineering Co., Inc., Clearwater, Fla.

Notes on implementation of Coulomb friction in coupled dynamical simulations p 67 N87-22746

E

Edighoffer, Inc., Newport News, Va.

Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0869] p 15 A87-33833

Dynamic analysis and experiment methods for a generic space station model p 22 A87-41813

Dynamic and thermal response finite element models of multi-body space structural configurations
[NASA-CR-178288] p 10 N87-24709

Electronique Serge Dassault, St. Cloud (France).

Study of expert system applications to space projects
[NE-61-687] p 115 N87-28057

Eloret Corp., Sunnyvale, Calif.

Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49815

Engineering, Inc., Hampton, Va.

The results of a limited study of approaches to the design, fabrication, and testing of a dynamic model of the NASA IOC space station. Executive summary
[NASA-CR-178276] p 8 N87-21020

Engineering Mechanics Associates, Inc., Torrance, Calif.

A computer program for modal verification of dynamic systems p 31 N87-22710

ERA Ltd., Leatherhead (England).

Radiation charging and breakdown of insulators p 143 N87-28854

Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).

A study of fluid transfer management in space
[FTMS-RPT-008] p 87 N87-28058

Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 38 N87-28075

European Space Agency, Paris (France).

Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-263] p 128 N87-20621

The Columbus program: An overview p 158 N87-20623

Servicing of the polar platform p 136 N87-20628

USA-Europe coordination and cooperation activities: Announcements of Opportunity p 170 N87-20632

Panel report on multidisciplinary instrumentation: New possibilities p 161 N87-20637

Panel report on new approaches to calibration and validation p 157 N87-20638

Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354

Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-28869

European Space Agency. ESRIN, Frascati (Italy).

Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20630

Data management panel report p 114 N87-20639

European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 128 N87-20622

Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 128 N87-20625

ESA Columbus polar platform design concept p 136 N87-20627

Orbit configurations p 158 N87-20629

Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects) p 128 N87-20631

The orbit configuration panel report p 157 N87-20640

Panel report on the polar platform servicing approach and its implications p 136 N87-20641

Electrostatic immunity of geostationary satellites p 143 N87-26857

Summary of recent SAR instrument studies p 159 N87-27885

Stopping differential charging of solar arrays p 83 N87-28884

Space 2000 in Europe p 159 N87-29024

F

Fairchild Space and Electronics Co., Germantown, Md.

Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-031] p 58 A87-32738

Ford Aerospace and Communications Corp., College Park, Md.

Integrated scheduling and resource management
[AIAA PAPER 87-2213] p 119 A87-48587

Fraunhofer-Inst. fuer Kurzzeitdynamik, Weil am Rhein (West Germany).

Micrometeorite impact on solar panels p 82 N87-28881

G

Galveston Coll., Tex.

Expansion of space station diagnostic capability to include serological identification of viral and bacterial infections p 53 N87-26703

Garrett Engine Co., Phoenix, Ariz.

Nuclear propulsion systems for orbit transfer based on the particle bed reactor
[DE87-010080] p 89 N87-26405

General Accounting Office, Washington, D. C.

Space operations: NASA's use of information technology. Report to the Chairman, Committee on Science, Space and Technology
[GAO/IMTEC-87-20] p 137 N87-22551

General Dynamics Corp., Fort Worth, Tex.

Large spacecraft pointing and shape control p 69 N87-24489

General Dynamics Corp., Huntsville, Ala.

Orbital transfer vehicle concept definition and system analysis study. Volume 1A: Executive summary. Phase 2
[NASA-CR-179081] p 101 N87-21016

General Dynamics Corp., San Diego, Calif.

National space transportation studies
[SAE PAPER 861691] p 100 A87-32586

Evaluation of cryogenic system test options for the OTV on-orbit propellant depot
[AIAA PAPER 87-1489] p 90 A87-43027

Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1540] p 44 A87-44843

Long term cryogenic storage facility systems study p 94 N87-21143

Control considerations for high frequency, resonant, power processing equipment used in large systems
[NASA-TM-88928] p 69 N87-23880

Design and demonstrate the performance of cryogenic components representative of space vehicles: Start basket liquid acquisition device performance analysis
[NASA-CR-179138] p 97 N87-26081

General Electric Co., Houston, Tex.

Integrated waste and water management system
[SAE PAPER 860998] p 51 A87-38773

General Electric Co., Philadelphia, Pa.

Science Research Facilities - Versatility for Space Station
[SAE PAPER 860958] p 119 A87-38742

The multi-disciplinary design study. A life cycle cost algorithm
[NASA-CR-178192] p 9 N87-21995

Impact of space station appendage vibrations on the pointing performance of gimbaled payloads p 32 N87-22733

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5). Volume 1A, part 1: Executive summary, phase 1
[NASA-CR-179139] p 97 N87-26082

System technology analysis of aeroassisted orbital transfer vehicles. Moderate lift/drag (0.75-1.5): Volume 1A, part 2: Executive summary, phase 2
[NASA-CR-179140] p 3 N87-26083

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 3: Cost estimates and work breakdown structure/dictionary, phase 1 and 2
[NASA-CR-179144] p 3 N87-26084

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5). Volume 2: Supporting research and technology report, phase 1 and 2
[NASA-CR-179143] p 3 N87-26085

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5),volume 1B, part 1, study results
[NASA-CR-179141] p 4 N87-26086

System technology analysis of aeroassisted orbital transfer vehicles: Moderate lift/drag (0.75-1.5), Volume 1B, part 2, study results
[NASA-CR-179142] p 4 N87-26087

General Electric Co., Schenectady, N.Y.

Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-45301

Genoa Univ. (Italy).

Organic Rankine cycle power conversion systems for space applications p 150 N87-28889

George Washington Univ., Washington, D.C.

Computational procedures for evaluating the sensitivity derivatives of vibration frequencies and Eigenmodes of framed structures
[NASA-CR-4089] p 40 N87-29869

Georgia Inst. of Tech., Atlanta.

Evaluation of Space Station thermal control techniques
[SAE PAPER 860999] p 42 A87-38775

Experiences with the Lanczos method on a parallel computer p 21 A87-41159

Optimal heading change with minimum energy loss for a hypersonic gliding vehicle
[AIAA PAPER 87-2568] p 139 A87-49818

Studies in nonlinear structural dynamics: Chaotic behavior and poynting effect p 28 N87-20548

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181030] p 45 N87-26072

Vibration control of flexible structures using piezoelectric devices as sensors and actuators p 37 N87-26387

Singular perturbation analysis of AOTV related trajectory optimization problems
[NASA-CR-180301] p 137 N87-26827

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-180312] p 45 N87-26939

Development of an emulation-simulation thermal control model for space station application
[NASA-CR-181221] p 45 N87-27702

Grumman Aerospace Corp., Bethpage, N.Y.

Advanced orbital servicing capabilities development
[SAE PAPER 860992] p 134 A87-38769

Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125

H

Hamilton Standard, Windsor Locks, Conn.

Maintenance components for Space Station long life fluid systems
[SAE PAPER 861005] p 89 A87-38779

Maintenance evaluation for space station liquid systems p 52 N87-21156

Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.

An advanced carbon reactor subsystem for carbon dioxide reduction
[SAE PAPER 860995] p 51 A87-38772

Harris Corp., Melbourne, Fla.
OPUS: Optimal Projection for Uncertain Systems
[AD-A178620] p 29 N87-21025
Maximum Entropy/Optimal Projection (MEOP) control design synthesis: Optimal quantification of the major design tradeoffs p 9 N87-22741
Harris Government Aerospace Systems Div., Melbourne, Fla.
Multiple beam phased array for Space Station Control Zone Communications p 85 A87-45519
Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
A three-mass tethered system for micro-g/variable-g applications p 125 A87-40858
Honeywell, Inc., Clearwater, Fla.
Automated Subsystem Control for Life Support System (ASCLSS)
[NASA-CR-172003] p 53 N87-29117
Honeywell Systems and Research Center, Minneapolis, Minn.
Robust control for large space antennas
p 67 N87-24499
Howard Univ., Washington, D. C.
A review of modelling techniques for the open and closed-loop dynamics of large space systems
p 12 A87-32337
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 123 A87-38567
Minimum time attitude slewing maneuvers of a rigid spacecraft
[NASA-CR-181130] p 72 N87-26038
The dynamics and control of large flexible space structures X, part 1
[NASA-CR-181287] p 73 N87-27712
Hughes Aircraft Co., Los Angeles, Calif.
Modeling of environmentally induced transients within satellites
[AIAA PAPER 85-0387] p 7 A87-41811
Hughes Aircraft Co., Torrance, Calif.
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32886

I

IIT Research Inst., Chicago, Ill.
Space stable thermal control coatings
[AD-A182798] p 110 N87-28584
Illinois Univ., Urbana.
Tracking and pointing maneuvers with slew-excited deformation shaping
[AIAA PAPER 87-2586] p 62 A87-50881
SAGA: A project to automate the management of software production systems
[NASA-CR-180275] p 10 N87-27412
Indian Inst. of Science, Bangalore.
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25358
Indian Space Research Organization, Bangalore.
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-25306
Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-25332
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-25373
International Fuel Cells Corp., South Windsor, Conn.
Advanced technology for extended endurance alkaline fuel cells p 75 A87-33787
Development of an alkaline fuel cell subsystem
[NASA-CR-172002] p 81 N87-29168
Advanced fuel cell concepts for future NASA missions
p 88 N87-29930
Iowa Univ., Iowa City.
Shape design sensitivity analysis and optimal design of structural systems
[NASA-CR-181098] p 37 N87-26370

J

Jet Propulsion Lab., California Inst. of Tech., Pasadena.
Validation of large space structures by ground tests
p 11 A87-32236
Static shape control for flexible structures
[SAE PAPER 861822] p 13 A87-32889
The Softmounted Inertially Reacting Pointing System (SIRPNT)
[AAS PAPER 86-007] p 56 A87-32732
Spacecraft dielectric material properties and spacecraft charging p 105 A87-33100
On orbit damage assessment for large space structures
[AIAA PAPER 87-0870] p 15 A87-33634
Dynamical response to pulse excitations in large space structures
[AIAA PAPER 87-0710] p 15 A87-33658
System identification of a truss type space structure using the multiple boundary condition test (MBCT) method
[AIAA PAPER 87-0746] p 16 A87-33670
On the control of flexible structures by applied thermal gradients
[AIAA PAPER 87-0867] p 16 A87-33706
Positive position feedback control for large space structures
[AIAA PAPER 87-0902] p 17 A87-33711
On sine dwell or broadband methods for modal testing
[AIAA PAPER 87-0861] p 18 A87-33752
Optimal placement of excitations and sensors for verification of large dynamical systems
[AIAA PAPER 87-0782] p 19 A87-33756
Design considerations for long-lived glass mirrors for space p 123 A87-36531
Geosynchronous earth orbit base propulsion - Electric propulsion options
[AIAA PAPER 87-0990] p 89 A87-38004
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 125 A87-38567
A survey of tether applications to planetary exploration
[AAS PAPER 86-228] p 123 A87-38588
Tether power supplies exploiting the characteristics of space
[AAS PAPER 86-227] p 123 A87-38571
Production of pulsed atomic oxygen beams via laser vaporization methods p 108 A87-38825
Degradation studies of SMRM teflon
p 108 A87-38841
Space environmental effects on adhesives for the Galileo spacecraft p 139 A87-38843
Control of flexible structures by applied thermal gradients p 21 A87-38943
Nuclear reactor power for an electrically powered orbital transfer vehicle
[AIAA PAPER 87-1102] p 78 A87-41145
Advanced propulsion activities in the USA
p 90 A87-41575
Soft mounted momentum compensated pointing system for the Space Shuttle Orbiter p 59 A87-42817
Remote sensing; Proceedings of the Meeting, Orlando, FL, Apr. 3, 4, 1986
[SPIE-644] p 125 A87-44176
Earth resources instrumentation for the Space Station Polar Platform p 129 A87-44184
Conceptual design of the High-Resolution Imaging Spectrometer (HIRIS) for EOS p 129 A87-44185
The Earth Observing System (EOS) synthetic aperture radar (SAR) p 129 A87-44187
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-48201
On the inadequacies of current multi-flexible body simulation codes
[AIAA PAPER 87-2248] p 7 A87-50412
Structural qualification of large spacecraft
p 28 N87-25331
Modal test and analysis: Multiple tests concept for improved validation of large space structure mathematical models p 8 N87-25381
Verification of large beam-type space structures
p 31 N87-22712
Verification of flexible structures by ground test
p 31 N87-22713
Structural dynamics system model reduction
p 32 N87-22727
Modeling of controlled flexible structures with impulsive loads p 33 N87-22745
On the control of structures by applied thermal gradients p 33 N87-22747
Control technology overview in CSI
p 68 N87-24507
Antenna Technology Shuttle Experiment (ATSE)
p 87 N87-24508
Structural control by the use of piezoelectric active members p 69 N87-24509
Ground test of large flexible structures
p 34 N87-24510
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89895] p 79 N87-25838
Proceedings of the NASA Workshop on Atomic Oxygen Effects
[NASA-CR-181163] p 141 N87-29173
O-atom degradation mechanisms of materials
p 141 N87-29179
Production of pulsed atomic oxygen beams via laser vaporization methods p 109 N87-29180
An electrically conductive thermal control surface for spacecraft encountering Low-Earth Orbit (LEO) atomic oxygen indium tin oxide-coated thermal blankets
p 45 N87-29192
Martin Marietta atomic oxygen Low Earth Orbit (LEO) simulation p 142 N87-29204
Advanced photovoltaic solar array design assessment
p 80 N87-29429
MAX: A space station computer option
p 116 N87-29146
Flight array processor p 116 N87-29148
JPL future missions and energy storage technology implications p 84 N87-29917
Johns Hopkins Univ., Laurel, Md.
Configuration tradeoffs for the space infrared telescope facility pointing control system p 121 A87-32238
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-001] p 58 A87-32735
Joint Oceanographic Inst., Inc., Washington, D.C.
A crisis in the NASA space and earth sciences programme p 112 A87-37668
Joint Publications Research Service, Arlington, Va.
Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735
Status of orbital astronomy projects
p 128 N87-21873
Plans for industrialization of space discussed
p 157 N87-21879
USSR Report: Space
[JPRS-USP-86-004] p 158 N87-27667
Pravda commentary, photos of Mir orbital station
p 158 N87-27668
IKI department head on orbital power plants
p 158 N87-27680
Progress in theory, technology of space materials science p 159 N87-27685
Optimizing experimental programs in operational planning of research carried out from spacecraft
p 160 N87-29553

L

Lawrence Livermore National Lab., Calif.
Toward the year 2000: The near future of the American civilian and military space programs
[DE87-006457] p 171 N87-22887
Life Systems, Inc., Cleveland, Ohio.
EDC development and testing for the Space Station program
[SAE PAPER 860918] p 118 A87-38710
A Space Station utility - Static Feed Electrolyzer
[SAE PAPER 860920] p 47 A87-38712
Environmental Control Life Support for the Space Station
[SAE PAPER 860944] p 48 A87-38731
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860984] p 51 A87-38771
LinCom Corp., Los Angeles, Calif.
FDMA system design and analysis for Space Station
p 85 A87-45483
Feasibility study on 8PSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel
p 113 A87-45486
Little (Arthur D.), Inc., Cambridge, Mass.
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720
Lockheed Engineering and Management Services Co., Inc., Houston, Tex.
Real-time simulation for Space Station
p 7 A87-37298
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720
Crew activity and motion effects on the space station
p 105 N87-22744
Lockheed Missiles and Space Co., Greenbelt, Md.
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50882
Lockheed Missiles and Space Co., Palo Alto, Calif.
Maximum likelihood identification using an array processor p 5 A87-32121
Spacecraft ram glow and surface temperature
p 10 N87-29205

Lockheed Missiles and Space Co., Sunnyvale, Calif.
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860853] p 164 A87-38740
Vibration isolation for line of sight performance improvement p 67 N87-22742
Preliminary design, analysis, and costing of a dynamic scale model of the NASA space station
[NASA-CR-4068] p 38 N87-25806
Test results from the solar array flight experiment
p 83 N87-29010
Los Alamos National Lab., N. Mex.
Radiation shielding requirements on long-duration space missions
[AD-A177512] p 140 N87-21881
Nuclear reactor power for a space-based radar. SP-100 project
[NASA-TM-89295] p 79 N87-25828
Lunar and Planetary Inst., Houston, Tex.
A crisis in the NASA space and earth sciences programme p 112 A87-37988

M

Management and Technical Services Co., Houston, Tex.
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 860869] p 164 A87-38751
Concepts for the evolution of the Space Station Program
[SAE PAPER 860872] p 120 A87-38754
Marconi Space Systems Ltd., Portsmouth (England).
GaAs concentrator solar arrays p 82 N87-26877
Martin Marietta Aerospace, Denver, Colo.
Benefits of passive damping as applied to active control of large space structures p 63 N87-20371
Near-field testing of the 5-meter model of the tetrahedral truss antenna
[NASA-CR-178147] p 30 N87-21887
Space station structural dynamics/reaction control system interaction study p 67 N87-22753
Box truss antenna technology status
p 67 N87-24500
Propulsion recommendations for space station free flying platforms p 99 N87-26129
Martin Marietta Corp., Denver, Colo.
Shuttle middeck fluid transfer experiment: Lessons learned p 95 N87-21158
Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn.
Traction-drive, seven-degree-of-freedom telerobot arm: A concept for manipulation in space p 104 N87-26087
Maryland Univ., College Park.
Dynamic finite element modeling of flexible structures
[AD-A177168] p 30 N87-22252
Massachusetts Inst. of Tech., Cambridge.
A crisis in the NASA space and earth sciences programme p 112 A87-37988
The radiation impedance of an electrodynamic tether with end connectors p 125 A87-42566
Flexible system model reduction and control system design based upon actuator and sensor influence functions p 59 A87-48201
Material damping in aluminum and metal matrix composites p 108 A87-48757
The coupled dynamics of fluids and spacecraft in low gravity and low gravity fluid measurement
p 94 N87-21147
A preliminary study of extended magnetic field structures in the ionosphere
[NASA-CR-181004] p 140 N87-23068
Development of intelligent structures using finite control elements in a hierarchic and distributed control system
[AD-A178711] p 72 N87-25008
Joint nonlinearity effects in the design of a flexible truss structure control system
[NASA-CR-180833] p 37 N87-26385
Design of a mixed fleet transportation system to low Earth orbit. Volume 1: Executive summary. Volume 2: Near-term shuttle replacement. Volume 3: Heavy-lift cargo vehicle. Volume 4: Advanced technology shuttle replacement p 5 N87-29503
Massachusetts Univ., Amherst.
Dynamic and thermal effects in very large space structures p 25 N87-20347
MATRA Espace, Paris-Velizy (France).
Study of data management system architecture options for space station
[MATRA-RF/176/0832-855-1] p 115 N87-26880
MATRA Espace, Toulouse (France).
Qualification of the faint object camera
p 127 N87-20358
Maxwell Labs., Inc., San Diego, Calif.
Fast ion scattering caused by Space Shuttle v x B induced differential charging p 140 A87-51713
McDonnell-Douglas Astronautics Co., Houston, Tex.
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2600] p 62 A87-50562
McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
The use of multidimensional scaling for facilities layout - An application to the design of the Space Station
p 118 A87-33003
Space Station galley design
[SAE PAPER 860832] p 119 A87-38722
Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860834] p 163 A87-38724
McDonnell-Douglas Astronautics Co., St. Louis, Mo.
Advanced EVA system design requirements study: EVAS/space station system interface requirements
[NASA-CR-171881] p 120 N87-20351
Messerschmitt-Boelkow-Blohm/Entwicklungsring Nord, Bremen (West Germany).
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357
Study of data management system architecture options for space station
[MATRA-RF/176/0832-855-1] p 115 N87-26880
Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
Stress and deformation analysis of lightweight composite structures
[MBB-UD-485/86] p 30 N87-22289
Botanical payloads for platforms and space stations
[MBB-UR-E-821/86] p 158 N87-25340
Possibilities of the further development of Columbus to an autonomous European space station
[MBB-UR-E-822/86] p 158 N87-25418
Fiber composites in satellites
[MBB-UD-482/86] p 107 N87-25430
The Restored Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25508
The evolution of a serviceable EURECA
[MBB-UR-E-823/86] p 121 N87-26841
Control engineering tasks in the framework of the Columbus program
[MBB-UR-E-812/86] p 156 N87-26842
Meteorological Office, Bracknell (England).
Ocean-ice panel report p 150 N87-20835
Michigan Univ., Ann Arbor.
Optimal nodal transfer and aeroassisted transfer by aerocruise p 138 N87-26577
Microsemi Corp., Torrance, Calif.
Space station power semiconductor package
[NASA-CR-180829] p 81 N87-28825

N

Naples Univ. (Italy).
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
National Academy of Sciences - National Research Council, Washington, D. C.
Guidelines for noise and vibration levels for the space station
[NASA-CR-178310] p 120 N87-24182
National Aeronautical Establishment, Ottawa (Ontario).
Use of a video-photogrammetry system for the measurement of the dynamic response of the shuttle remote manipulator arm p 101 N87-20370
National Aeronautics and Space Administration, Washington, D.C.
Space research - At a crossroads
p 165 A87-32017
NASA's space program - Space Station: A status report and a view of its value for space science
p 1 A87-32277
Overview of the NASA automation and robotics research program p 100 A87-33667
A crisis in the NASA space and earth sciences programme p 112 A87-37988
Tethers in space; Proceedings of the International Conference, Arlington, VA, Sept. 17-19, 1986
p 123 A87-38867
Technology and applications - Convergence to a tether capability
[AAS PAPER 86-244] p 124 A87-38874
Radiation dose prediction for Space Station
[SAE PAPER 860824] p 139 A87-38715
The Space Station overview p 105 A87-41571
The evolution of the geostationary platform concept
p 125 A87-43154
Scientific customer needs - NASA user
[AIAA PAPER 87-2188] p 119 A87-48582
The Consultative Committee for Space Data Systems Standards program
[AIAA PAPER 87-2204] p 113 A87-48589
The Space Station software support environment - Not just what, but why
[AIAA PAPER 87-2208] p 114 A87-48590
Technical and Management Information System (TMIS)
[AIAA PAPER 87-2217] p 114 A87-48600
Future trends in spacecraft design and qualification
p 2 N87-20356
Space station: A program overview
p 171 N87-24488
Large space systems technology and requirements
p 3 N87-24500
Space station systems: A bibliography with indexes (supplement 4)
[NASA-SP-7056(04)] p 4 N87-26073
An overview of photovoltaic applications in space
p 80 N87-29414
Proceedings: Computer Science and Data Systems Technical Symposium, volume 1
[NASA-TM-89285] p 116 N87-29124
Proceedings: Computer Science and Data Systems Technical Symposium, volume 2
[NASA-TM-89286] p 116 N87-29144
Advanced local area network concepts
p 117 N87-29153
National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
Maximum likelihood identification using an array processor p 5 A87-32121
Design and development of a Space Station proximity operations research and development mockup
[SAE PAPER 861786] p 120 A87-32634
Transferring superfluid helium in space
p 88 A87-34712
Integrated air revitalization system for Space Station
[SAE PAPER 860946] p 48 A87-38733
Science and payload options for animal and plant research accommodations aboard the early Space Station
[SAE PAPER 860853] p 164 A87-38740
Life Sciences Research Facility automation requirements and concepts for the Space Station
[SAE PAPER 860870] p 50 A87-38752
Life Science Research Facility materials management requirements and concepts
[SAE PAPER 860874] p 124 A87-38756
Development of a water recovery subsystem based on Vapor Phase Catalytic Ammonia Removal (VPCAR)
[SAE PAPER 860986] p 50 A87-38794
Proof that timing requirements of the FDDI token ring protocol are satisfied p 112 A87-43521
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49815
An astrometric facility for planetary detection on the Space Station p 127 A87-50750
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53502
An astrometric facility for planetary detection on the space station
[NASA-TM-89435] p 128 N87-20941
Helium technology issues p 94 N87-21148
Astrometric Telescope Facility: Preliminary systems definition study report. Volume 2: Technical description
[NASA-TM-89429-VOL-2] p 129 N87-22570
Astrometric Telescope Facility preliminary systems definition study. Volume 1: Executive summary
[NASA-TM-89429-VOL-1] p 129 N87-22571
Human factors in space station architecture 2. EVA access facility: A comparative analysis of 4 concepts for on-orbit space suit servicing
[NASA-TM-86856] p 52 N87-24084
Workshop on Workload and Training, and Examination of their Interactions: Executive summary
[NASA-TM-89450] p 171 N87-25768
Potential energy surfaces for atomic oxygen reactions: Formation of singlet and triplet biradicals as primary reaction products with unsaturated organic molecules
p 109 N87-28182
Reactions of atomic oxygen (O(3P)) with polybutadienes and related polymers p 109 N87-28187
Potential surfaces for O atom-polymer reactions
p 109 N87-28201
Network reliability p 117 N87-29157
National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
Space Infrared Telescope Facility/Multimission Modular Spacecraft Attitude Control System conceptual design
[AAS PAPER 86-091] p 59 A87-32739
Potential modulation on the SCATHA spacecraft
p 139 A87-34480

Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860673] p 134 A87-26755
Actuators for actively controlled space structures
p 59 A87-42816
Earth resources instrumentation for the Space Station Polar Platform p 128 A87-44184
Preliminary system concepts for MODIS - A moderate resolution imaging spectrometer for EOS
p 128 A87-44188
Feasibility study on BPSK, QPSK, TFM, by using CLASS for Space Station/TDRSS real measured channel
p 113 A87-45485
Control of robot manipulator compliance
p 105 A87-45797
Data storage systems technology for the Space Station era
[AIAA PAPER 87-2202] p 113 A87-48587
Data capture and processing
[AIAA PAPER 87-2203] p 113 A87-48588
Standards for the user interface - Developing a user consensus
[AIAA PAPER 87-2209] p 169 A87-48594
The dynamics and control of the Space Station polar platform
[AIAA PAPER 87-2890] p 62 A87-50562
The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53082
Gas tungsten arc welding in a microgravity environment: Work done on GAS payload G-169 p 139 N87-20308
Superfluid helium on orbit transfer (SHOOT)
p 95 N87-21151
Problems in merging Earth sensing satellite data sets
[NASA-TM-87820] p 129 N87-23457
TAE Plus: A conceptual view of TAE in the space station era p 8 N87-23157
SOT: A rapid prototype using TAE windows
p 114 N87-23161
High energy gamma ray astronomy
p 129 N87-24258
Dynamics during thrust maneuvers of flexible spinning satellites with axial and radial booms p 71 N87-25358
Mass storage systems for data transport in the early space station era 1992-1998
[NASA-TM-87829] p 115 N87-27443
Fiber optic data systems p 117 N87-29152
User interface and payload command and control
p 73 N87-29162
User data management p 4 N87-29163
Advanced software tools space station focused technology p 5 N87-29164
SS focused technology: Gateways and NOS's
p 117 N87-29165
Network operating system p 117 N87-29166
LEO and GEO missions p 5 N87-29916
National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
Quick-disconnect inflatable seal assembly
[NASA-CASE-KSC-11368-1] p 102 N87-25583
KSC Space Station Operations Language (SSOL)
p 135 N87-29169
National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
Space Station integration and verification concepts
p 84 A87-21481
Selected materials issues associated with Space Station p 105 A87-22201
Role of the manned manoeuvering unit for the Space Station
[SAE PAPER 861834] p 138 A87-22687
System level verification applying the Space Shuttle experience to the Space Station
[AAS PAPER 86-031] p 86 A87-32737
Laser docking system flight experiment
[AAS PAPER 86-043] p 99 A87-32745
System architecture for the telerobotic work system
[AAS PAPER 86-044] p 99 A87-32746
Manned space flight p 167 A87-35019
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731
Manned spacecraft electrical power systems
p 75 A87-37291
Space Station data management system architecture
p 111 A87-37293
Space station data management system - A common GSE test interface for systems testing and verification
p 112 A87-37294
Shuttle orbit flight control design lessons - Direction for Space Station p 58 A87-37295
Space Station communications and tracking system
p 134 A87-37297
Real-time simulation for Space Station
p 7 A87-37298
Manned spacecraft automation and robotics
p 100 A87-37300
Electrodynamic plasma motor/generator experiment
[AAS PAPER 86-212] p 89 A87-38569
Plasma motor/generator reference system designs for power and propulsion
[AAS PAPER 86-229] p 89 A87-38572
Space motion sickness status report
[SAE PAPER 860923] p 163 A87-38714
Space Station Food System
[SAE PAPER 860930] p 46 A87-38720
Space Station personal hygiene study
[SAE PAPER 860931] p 163 A87-38721
Space Station galley design
[SAE PAPER 860932] p 119 A87-38722
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734
Conceptual planning for Space Station life sciences human research project
[SAE PAPER 860969] p 164 A87-38751
Concepts for the evolution of the Space Station Program
[SAE PAPER 860972] p 120 A87-38754
Pre- and post-treatment techniques for spacecraft water recovery
[SAE PAPER 860982] p 50 A87-38761
Results on reuse of reclaimed shower water
[SAE PAPER 860983] p 50 A87-38762
A membrane-based subsystem for very high recoveries of spacecraft waste waters
[SAE PAPER 860984] p 50 A87-38763
Environmental control and life support technologies for advanced manned space missions
[SAE PAPER 860994] p 51 A87-38771
An advanced carbon reactor subsystem for carbon dioxide reduction
[SAE PAPER 860995] p 51 A87-38772
Integrated waste and water management system
[SAE PAPER 860998] p 51 A87-38773
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38784
The mechanics of manufacturing in space
p 167 A87-40088
Experimentation in planetary geology
p 124 A87-40819
Advanced technology for the Space Station
p 120 A87-40853
Inadequacy of single-impulse transfers for path constrained rendezvous p 80 A87-41615
Optical correlator use at Johnson Space Center
p 58 A87-42868
The definition of the low earth orbital environment and its effect on thermal control materials
[AIAA PAPER 87-1599] p 43 A87-43103
Thermal test results of the two-phase thermal bus technology demonstration loop
[AIAA PAPER 87-1627] p 44 A87-43125
Development of a prototype two-phase thermal bus system for Space Station
[AIAA PAPER 87-1628] p 44 A87-43126
Structural and preliminary thermal performance testing of a pressure activated contact heat exchanger
[AIAA PAPER 87-1640] p 44 A87-44843
FDMA system design and analysis for Space Station
p 85 A87-45483
Space Station multiple access communications system p 86 A87-45524
Man's role in space exploration and exploitation
p 169 A87-46332
Space Station Information System integrated communications concept
[AIAA PAPER 87-2226] p 114 A87-48606
Space Station Information System requirements for integrated communications
[AIAA PAPER 87-2230] p 114 A87-48607
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-48608
Proposed CMG momentum management scheme for space station
[AIAA PAPER 87-2528] p 62 A87-50531
Space station control moment gyro control
p 64 N87-20333
Aero-Assisted Orbital Transfer Vehicle (AOTV)
p 3 N87-20582
Microgravity fluid management in two-phase thermal systems p 95 N87-21152
Track and capture of the orbiter with the space station remote manipulator system
[NASA-TM-88921] p 107 N87-25339
Collet lock joint for space station truss
[NASA-CASE-MSC-21207-1] p 38 N87-25576
Preloadable vector sensitive latch
[NASA-CASE-MSC-20910-1] p 161 N87-25582
Review of Low Earth Orbital (LEO) flight experiments
p 131 N87-29174
Material interactions with the Low Earth Orbital (LEO) environment: Accurate reaction rate measurements
p 108 N87-29175
Mass spectrometers and atomic oxygen
p 141 N87-29176
High intensity 5-eV atomic oxygen source and Low Earth Orbit (LEO) simulation facility p 141 N87-29188
Quality requirements for reclaimed/recycled water
[NASA-TM-58279] p 53 N87-27392
Space suit extravehicular hazards protection development
[NASA-TM-100350] p 53 N87-27407
Testing and analysis of DOD Ada language products for NASA p 172 N87-29155
Network operating system focus technology
p 117 N87-29167
The 21st Aerospace Mechanisms Symposium
[NASA-CP-2470] p 103 N87-29858
Telerobotic work system: Concept development and evolution p 104 N87-29866
The preloadable vector sensitive latch for orbital docking/berthing p 152 N87-29875
An electromechanical attenuator/actuator for Space Station docking p 138 N87-29876
Space Station lubrication considerations
p 104 N87-29879
National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
Robust controller synthesis for a large flexible space antenna p 84 A87-22226
High capacity demonstration of honeycomb panel heat pipes
[SAE PAPER 861833] p 41 A87-32893
A Lanczos eigenvalue method on a parallel computer
[AIAA PAPER 87-0725] p 13 A87-33066
Integrated structural electromagnetic optimization of large space antenna reflectors
[AIAA PAPER 87-0824] p 14 A87-33811
Optimization procedure to control the coupling of vibration modes in flexible space structures
[AIAA PAPER 87-0826] p 14 A87-33813
Quasi-static shape adjustment of a 15 meter diameter space antenna
[AIAA PAPER 87-0930] p 15 A87-33823
Vibration suppression using a constrained rate-feedback threshold control strategy
[AIAA PAPER 87-0741] p 6 A87-33826
Experience in distributed parameter modeling of the Spacecraft Control Laboratory Experiment (SCOLE) structure
[AIAA PAPER 87-0885] p 16 A87-33859
Dynamic and attitude control characteristics of an International Space Station
[AIAA PAPER 87-0931] p 57 A87-33731
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739
Thermal design of the ACCESS erectable space truss
p 42 A87-34489
Composite tubes for the Space Station truss structure
p 20 A87-38891
Assessment of space environment induced microdamage in toughened composite materials
p 20 A87-38889
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration
[SAE PAPER 860916] p 47 A87-38759
Supercritical water oxidation - Concept analysis for evolutionary Space Station application
[SAE PAPER 860993] p 51 A87-38770
Evaluation of Space Station thermal control techniques
[SAE PAPER 860999] p 42 A87-38775
Experiences with the Lanczos method on a parallel computer p 21 A87-41109
Dynamic analysis and experiment methods for a generic space station model p 22 A87-41613
Interdisciplinary analysis procedures in the modeling and control of large space-based structures
p 22 A87-42570
Effects of atmosphere on slewing control of a flexible structure p 22 A87-47620
Robust eigenvalue assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416
Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2507] p 24 A87-50471
On-line identification and attitude control for SCOLE
[AIAA PAPER 87-2458] p 61 A87-50505
Distributed parameter modeling of the structural dynamics of the Solar Array Flight Experiment
[AIAA PAPER 87-2480] p 25 A87-50509
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52482

263

A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53079
Effects of space plasma discharge on the performance of large antenna structures in low Earth orbit [NASA-TM-89118] p 86 N87-20339
Large space antennas: A systems analysis case history [NASA-TM-89072] p 26 N87-20352
Modeling of joints for the dynamic analysis of truss structures [NASA-TP-2661] p 28 N87-20567
Documentation of the space station/aircraft acoustic apparatus [NASA-TM-89111] p 140 N87-20795
Analysis of on-orbit thermal characteristics of the 15-meter hoop/column antenna [NASA-TM-89137] p 45 N87-21021
Measurement apparatus and procedure for the determination of surface emissivities [NASA-CASE-LAR-13455-1] p 29 N87-21208
Status of the Mast experiment p 30 N87-22703
Microprocessor controlled proof-mass actuator p 65 N87-22708
Considerations in the design and development of a space station scale model p 9 N87-22711
Status report and preliminary results of the spacecraft control laboratory experiment p 66 N87-22717
An overview of controls research on the NASA Langley Research Center grid p 66 N87-22720
Control of flexible structures and the research community p 66 N87-22732
Dual keel space station control/structures interaction study p 67 N87-22737
Slewing control experiment for a flexible panel p 76 N87-22740
Optimization of payload mass placement in a dual keel space station [NASA-TM-89081] p 68 N87-23667
NASA/DOD Control/Structures Interaction Technology, 1986 [NASA-CP-2447-PT-2] p 34 N87-24485
Design, construction, and utilization of a space station assembled from 5-meter erectable struts p 34 N87-24501
Controls-structures-electromagnetics interaction program p 69 N87-24502
Hoop/column and tetrahedral truss electromagnetic tests p 67 N87-24504
COFS 3 multibody dynamics and control technology p 69 N87-24508
Slew maneuvers on the SCOLE Laboratory Facility p 69 N87-24511
Research in slewing and tracking control p 70 N87-24512
Deployable geodetic truss structure [NASA-CASE-LAR-13113-1] p 38 N87-25492
Vapor fragrancer [NASA-CASE-LAR-13880-1] p 165 N87-25681
Experimental evaluation of small-scale erectable truss hardware [NASA-TM-89088] p 37 N87-26086
Preloaded space structural coupling joints [NASA-CASE-LAR-13489-1] p 38 N87-27713
Mobile remote manipulator vehicle system [NASA-CASE-LAR-13393-1] p 103 N87-29118
Distributed computer taxonomy based on O/S structure p 116 N87-29127
A workstation environment for software engineering p 116 N87-29128
Engineering graphics and image processing at Langley Research Center p 10 N87-29129
A VHSIC general purpose processor p 116 N87-29145
Information network architectures p 116 N87-29149
Video image processing p 116 N87-29150
Fiber optics wavelength division multiplexing(components) p 117 N87-29151
Fiber optics common transceiver module p 117 N87-29160
Electronic control/display interface technology p 66 N87-29161
Technology for Large Space Systems. A bibliography with indexes (supplement 17) [NASA-SP-7046(17)] p 39 N87-29576
Space Station end effector strategy study [NASA-TM-100469] p 103 N87-29880
A spline-based parameter and state estimation technique for static models of elastic surfaces [NASA-CR-180449] p 11 N87-30107

National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter [ASME PAPER 86-GT-100] p 168 A87-25308
Hollow cathode-based plasma contactor experiments for electrodynamic tether [AIAA PAPER 87-0572] p 121 A87-32192
Advanced technology for extended endurance alkaline fuel cells p 75 A87-33787
Space Station 20-kHz power management and distribution system p 75 A87-36913
Manned spacecraft electrical power systems p 75 A87-37291
Composite space antenna structures - Properties and environmental effects p 20 A87-38810
20 kHz Space Station power system p 76 A87-40376
Resistojet control and power for high frequency ac buses [AIAA PAPER 87-0994] p 58 A87-41103
Liquid sheet radiator [AIAA PAPER 87-1525] p 43 A87-43048
Liquid droplet radiator development status [AIAA PAPER 87-1537] p 43 A87-43058
An advanced geostationary communications platform p 125 A87-43186
Conceptual design and integration of a Space Station resistojet propulsion assembly [AIAA PAPER 87-1860] p 91 A87-45258
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [AIAA PAPER 87-1764] p 92 A87-48572
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [AIAA PAPER 87-2120] p 93 A87-50187
Temperature fields due to jet induced mixing in a typical OTV tank [AIAA PAPER 87-2017] p 93 A87-52247
Effect of nozzle geometry on the resistojet exhaust plume [AIAA PAPER 87-2121] p 62 A87-52252
Fire safety concerns in space operations [NASA-TM-89848] p 165 N87-20342
Liquid droplet radiator development status [NASA-TM-89852] p 44 N87-20353
Conceptual design and integration of a space station resistojet propulsion assembly [NASA-TM-88847] p 93 N87-20376
Resistojet control and power for high frequency ac buses [NASA-TM-89880] p 63 N87-20477
Microgravity Fluid Management Symposium [NASA-CP-2465] p 94 N87-21141
Cryogenic Fluid Management Flight Experiment (CFMFE) p 95 N87-21150
Space station electric power system requirements and design [NASA-TM-89889] p 88 N87-22001
Coaxial tube array space transmission line characterization [NASA-TM-88864] p 69 N87-22003
EMC and power quality standards for 20-kHz power distribution [NASA-TM-89825] p 78 N87-22004
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems [NASA-TM-89886] p 76 N87-22174
A 2000-hour cyclic endurance test of a laboratory model multipropellant resistojet [NASA-TM-89864] p 98 N87-22237
Thermodynamic analysis and subscale modeling of space-based orbit transfer vehicle cryogenic propellant resupply [NASA-TM-89921] p 96 N87-22949
Performance characteristics of a combination solar photovoltaic heat engine energy converter [NASA-TM-89898] p 78 N87-23089
Speculations on future opportunities to evolve Brayton powerplants aboard the space station [NASA-TM-89893] p 121 N87-23874
Control considerations for high frequency, resonant, power processing equipment used in large systems [NASA-TM-89895] p 66 N87-23890
Oxidation protection coatings for polymers [NASA-CASE-LEW-14072-2] p 107 N87-23730
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application [NASA-TM-100113] p 98 N87-23821
Resistojet plume and induced environment analysis [NASA-TM-88857] p 98 N87-24532
Effect of component compression on the initial performance of an IPV nickel-hydrogen cell [NASA-TM-100102] p 79 N87-24599
Space station propulsion system technology [NASA-TM-100108] p 97 N87-25422
An evaluation of candidate oxidation resistant materials for space applications in LEO [NASA-TM-100122] p 107 N87-25480
Nuclear reactor power for a space-based radar. SP-100 project [NASA-TM-89295] p 79 N87-25838
Proven, long-life hydrogen/oxygen thrust chambers for space station propulsion p 98 N87-26133
Water-propellant resistojets for man-tended platforms [NASA-TM-100110] p 98 N87-26135
Space station electrical power system [NASA-TM-100140] p 80 N87-26144
Neutral atomic oxygen beam produced by ion charge exchange for Low Earth Orbital (LEO) simulation p 131 N87-26188
An evaluation of candidate oxidation resistant materials p 110 N87-26203
Space station power system p 80 N87-26447
Electrodynamic tether p 131 N87-26449
High power/large area PV systems p 80 N87-26452
The space station power system p 81 N87-26880
Alternative power generation concepts for space p 81 N87-26881
Space Electrochemical Research and Technology (SERT) [NASA-CP-2484] p 5 N87-29914
Status of space station power system p 84 N87-29915

National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
A space debris simulation facility for spacecraft materials evaluation p 11 A87-32058
National space transportation studies [SAE PAPER 861681] p 160 A87-32589
Prototype thermal bus for manned Space Station compartments [SAE PAPER 861625] p 41 A87-32699
Use of the Orbital Maneuvering Vehicle (OMV) for placement and retrieval of spacecraft and platforms [AAS PAPER 86-041] p 133 A87-32743
Solar array flight dynamic experiment [AAS PAPER 86-050] p 75 A87-32747
Potential modulation on the SCATHA spacecraft p 139 A87-34480
Space Station environmental control and life support system distribution and loop closure studies [SAE PAPER 860942] p 48 A87-35729
Status of the Space Station environmental control and life support system design concept [SAE PAPER 860943] p 48 A87-35730
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs [SAE PAPER 860987] p 51 A87-35768
Advanced orbital servicing capabilities development [SAE PAPER 860992] p 134 A87-35769
Maintenance components for Space Station long life fluid systems [SAE PAPER 861005] p 88 A87-35775
Evaluation of cryogenic system test options for the OTV on-orbit propellant depot [AIAA PAPER 87-1488] p 90 A87-43027
Space Station propulsion system test bed and control system testing results [AIAA PAPER 87-1858] p 91 A87-45255
Adaptive momentum management for the dual keel Space Station [AIAA PAPER 87-2588] p 62 A87-50508
Solar array flight experiment/dynamic augmentation experiment [NASA-TP-2690] p 63 N87-20360
Space station structures and dynamics test program [NASA-TP-2710] p 28 N87-20563
SAFE/DAE: Modal test in space p 77 N87-20564
Upper and Middle Atmospheric Density Modeling Requirements for Spacecraft Design and Operations [NASA-CP-2460] p 64 N87-20885
Space station momentum management p 64 N87-20889
Advanced long term cryogenic storage systems p 94 N87-21142
Equations of motion of a space station with emphasis on the effects of the gravity gradient [NASA-TM-89093] p 64 N87-21880
Structural Dynamics and Control Interaction of Flexible Structures [NASA-CP-2467-PT-1] p 65 N87-22702
Large space structures ground experiment checkout p 30 N87-22704
Commit your works to the Lord, and your thoughts shall be established (Prov. 16:3). Inter-stable control systems p 9 N87-22716
Solar array flight dynamic experiment p 75 N87-22722
Dynamic characteristics of a vibrating beam with periodic variation in bending stiffness p 32 N87-22729

Workshop on Structural Dynamics and Control Interaction of Flexible Structures p 32 N87-22728
Structural Dynamics and Control Interaction of Flexible Structures
[NASA-CP-2467-PT-2] p 66 N87-22729
A TREETOPS simulation of the Hubble Space Telescope-High Gain Antenna interaction
p 9 N87-22735
System identification for large space structure damage assessment p 33 N87-22750
Space station structures and dynamics test program
p 33 N87-22751
Large space structures testing
[NASA-TM-100306] p 35 N87-24520
Distributed control using linear momentum exchange devices
[NASA-TM-100308] p 70 N87-24521
Characterization and hardware modification of linear momentum exchange devices
[NASA-TM-88834] p 70 N87-24723
Bi-stem gripping apparatus
[NASA-CASE-MFS-28185-1] p 107 N87-25586
Space station propulsion test bed: A complete system
p 98 N87-26131
A 25-LBF gaseous oxygen/gaseous hydrogen thruster for space station application p 98 N87-26132
NASA Marshall Space Flight Center atomic oxygen investigations p 109 N87-26202

National Aeronautics and Space Administration. Pasadena Office, Calif.
Variable energy, high flux, ground-state atomic oxygen source
[NASA-CASE-NPO-16640-1-CU] p 6 N87-21881

National Bureau of Standards, Gaithersburg, Md.
Kinetics and mechanisms of some atomic oxygen reactions p 141 N87-26179

National Center for Atmospheric Research, Boulder, Colo.
A crisis in the NASA space and earth sciences programme p 112 A87-27968

National Oceanic and Atmospheric Administration, Washington, D. C.
Planning for future operational sensors and other priorities
[NOAA-NESDIS-30] p 130 N87-25560

Naval Postgraduate School, Monterey, Calif.
The effect of multipath on digital communications systems: With application to space station
[AD-A178578] p 86 N87-22676
Dynamic analysis of the flexible boom in the N-ROSS satellite
[AD-A181488] p 72 N87-26066
Computer simulation of a rotational single-element flexible spacecraft boom
[AD-A181798] p 100 N87-26069

Nevada Univ., Las Vegas.
Robust nonlinear attitude control of flexible spacecraft
p 60 A87-46273

New Mexico Univ., Albuquerque.
An analysis of bipropellant neutralization for spacecraft refueling operations p 97 N87-25696

Northrop Services, Inc., Houston, Tex.
Results on reuse of reclaimed shower water
[SAE PAPER 860993] p 50 A87-38762

O

Oak Ridge National Lab., Tenn.
The Oak Ridge National Laboratory's Robotics and Intelligent Systems Program
[DE87-004627] p 101 N87-20774
Application of a traction-drive 7-degrees-of-freedom telerobot to space manipulation
[DE87-004616] p 101 N87-22231
Traction-drive telerobot for space manipulation
[DE87-005326] p 102 N87-22233
Telerobotic technology for nuclear and space applications
[NASA-CR-180623] p 102 N87-22242
Application of advanced flywheel technology for energy storage on space station
[DE87-007657] p 69 N87-24026
Remote handling facility and equipment used for space truss assembly
[DE87-008121] p 103 N87-27400
Application of advanced flywheel technology for energy storage on space station p 74 N87-29033

OAO Corp., Greenbelt, Md.
Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32692

Office of Technology Assessment, Washington, D.C.
Space stations and the law: Selected legal issues
[PB87-118220] p 171 N87-21764

Ohio State Univ., Columbus.
Progress on the Ohio State University Get Away Special G-0318: DEAP p 170 N87-20011
Variable structure control system maneuvering of spacecraft p 64 N87-21869

Old Dominion Univ., Norfolk, Va.
Robust controller synthesis for a large flexible space antenna p 64 A87-32235
Practical implementation of an accurate method for multilevel design sensitivity analysis
[AIAA PAPER 87-0718] p 6 A87-33080
Single-mode projection filters for identification and state estimation of flexible structures
[AIAA PAPER 87-2387] p 24 A87-50471
Projection filters for modal parameter estimate for flexible structures
[NASA-CR-180303] p 38 N87-26583
Substructure analysis using NICE/SPAR and applications of force to linear and nonlinear structures
[NASA-CR-180317] p 38 N87-27260

Open Univ., Oxford (England).
Ideas for educational physics experiments in space
p 130 N87-25033

Operations Research, Inc., Silver Spring, Md.
Servicing of user payload equipment in the Space Station pressurized environment
[SAE PAPER 860673] p 134 A87-38755

P

Perkin-Elmer Corp., Danbury, Conn.
Optical arrays for future astronomical telescopes in space p 128 A87-44533

Physical Sciences, Inc., Andover, Mass.
A high flux pulsed source of energetic atomic oxygen
p 139 A87-39623
Pulsed source of energetic atomic oxygen
p 158 N87-26180
Chemical interactions in Low Earth Orbit (LEO)
p 159 N87-26188

Physikalisch-Technische Bundesanstalt, Brunswick (West Germany).
Absolute indoor calibration of large area solar cells
p 159 N87-29015

Politecnico di Milano (Italy).
Active structural controllers emulating structural elements by ICUs p 27 N87-22587
Automatic docking maneuver and attitude control system p 71 N87-25305

Prairie View Agricultural and Mechanical Coll., Tex.
Space station electrical power distribution analysis using a load flow approach p 80 N87-26889

PRC Kentron, Inc., Hampton, Va.
Effects of local vibrations on the dynamics of space truss structures
[AIAA PAPER 87-0941] p 17 A87-33739
Interdisciplinary analysis procedures in the modeling and control of large space-based structures
p 22 A87-42678

Princeton Univ., N. J.
Groundbased studies of spacecraft glow and erosion caused by impact of oxygen and nitrogen beams
p 109 N87-26200

Purdue Univ., West Lafayette, Ind.
The effect of circumferential aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter
[ASME PAPER 86-GT-100] p 165 A87-25388
Preliminary performance characterizations of an engineering model multipropellant resistojet for space station application
[AIAA PAPER 87-2120] p 93 A87-50187
Use of lightweight composites for GAS payload structures p 25 N87-20307

R

RCA Aerospace and Defense, East Windsor, N.J.
Development of a standard connector for orbital replacement units for serviceable spacecraft
p 40 N87-26064

RCA Astro-Electronics Div., Princeton, N. J.
Design of an advanced two-phase capillary cold plate
[SAE PAPER 861829] p 41 A87-32692

RCA Communications Systems Div., Camden, N. J.
Multiple Access Ku-band communications subsystem for the Space Station p 84 A87-31402

Rice Univ., Houston, Tex.
Optimal trajectories for aeroassisted, coplanar orbital transfer p 54 A87-31601

Rochester Univ., N. Y.
Self-calibration strategies for robot manipulators
p 102 N87-26030

Rockwell International Corp., Canoga Park, Calif.
Concepts for space maintenance of OTV engines
p 135 A87-41181
Space Station propulsion system test bed and control system testing results
[AIAA PAPER 87-1856] p 91 A87-45256
Concepts for space maintenance of OTV engines
p 136 A87-48000
Density uncertainty effect on cost of space station reboost p 170 N87-20667
Space station WP-04 power system. Volume 1: Executive summary
[NASA-CR-179587-VOL-1] p 78 N87-23695
Space station WP-04 power system. Volume 2: Study results
[NASA-CR-179587-VOL-2] p 79 N87-23696
Concepts for space maintenance of OTV engines
p 137 N87-26067
Hydrogen/oxygen economy for the space station
p 98 N87-26130

Rockwell International Corp., Downey, Calif.
Structural/control interaction (payload pointing and micro-g) p 9 N87-22721
Preliminary evaluation of a reaction control system for the space station p 67 N87-22736
The design and development of a mobile transporter system for the Space Station Remote Manipulator System p 104 N87-29868
Space Station based options for orbiter docking/berthing p 138 N87-29877

Rockwell International Corp., Houston, Tex.
Radiation environments and absorbed dose estimations on manned space missions p 139 A87-48229

Rome Air Development Center, Hanscom AFB, Mass.
Spacecraft dielectric material properties and spacecraft charging p 105 A87-33105

Rome Univ. (Italy).
Effect of modal damping in modal synthesis of spacecraft structures p 28 N87-20054
Sampled nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25308

Royal Aircraft Establishment, Farnborough (England).
The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-29942

Royal Netherlands Aircraft Factories Fokker, Amsterdam.
End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC)
[FOK-TR-R-86-091-VOL-2] p 102 N87-24469
End effector development study, volume 1
[FOK-TR-R-86-091-VOL-1] p 102 N87-25335
End effector development study. Volume 3: Appendices
[FOK-TR-R-86-091-VOL-3] p 102 N87-25337
The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-29975
The Fokker Strongback solar array p 82 N87-29979

Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.
Acoustic effects on the dynamic of lightweight structures p 28 N87-29972
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 82 N87-29973

S

Science and Engineering Associates, Inc., Englewood, Colo.
Contamination assessment for OSSA space station IOC payloads
[NASA-CR-4091] p 53 N87-26598

Science Applications International Corp., Schaumburg, Ill.
Satellite servicing mission preliminary cost estimation model
[NASA-CR-171979] p 139 N87-26026

Science Research Council, Chilton (England).
Report of the atmosphere panel p 161 N87-26833

Search for Extraterrestrial Intelligence Inst., Los Altos, Calif.
Space Station gas-grain simulation facility - Application to exobiology p 127 A87-53032

Selenia S.p.A., Rome (Italy).
Data management system architecture options for space stations
[SES/DNP/TR/002/86] p 115 N87-26535
Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/ENG/ES-016/86] p 136 N87-26608

Sener S.A., Madrid (Spain).
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2317] p 103 N87-26283

Severn Communications Corp., Severna Park, Md.
Radiation shielding requirements on long-duration space missions
[AD-A177512] p 140 N87-21881

Shock and Vibration Information Center (Defense), Washington, D. C.
The Shock and Vibration Bulletin. Part 1: Welcome, Invited Papers, Shipboard Shock, Blast and Ground Shock, Shock Testing and Analysis
[AD-A175224] p 25 N87-20574

Smithsonian Astrophysical Observatory, Cambridge, Mass.
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-180602] p 129 N87-22509
Analytical investigation of the dynamics of tethered constellations in Earth orbit, phase 2
[NASA-CR-179146] p 130 N87-26883
Investigation of plasma contactors for use with orbiting wires
[NASA-CR-181422] p 131 N87-29581

Societe Europeenne de Propulsion, Vernon (France).
SPOT/MEGS design and flight results obtained
p 103 N87-29009
Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29008

Societe Nationale Industrielle Aerospatiale, Cannes (France).
Dynamic modelling and optimal control design for large flexible space structures p 26 N87-20300
Dynamic analysis of direct television satellite TV-SAT/TDF.1 p 66 N87-20360
SPOT solar array in-orbit deployment results evaluation p 63 N87-29006
Aerospatiale solar arrays, in orbit performance
p 159 N87-29008
Computer simulation of deployment
p 10 N87-29002

Southern California Inst. of Architecture, Santa Monica.
Space station group activities habitability module study
[NASA-CR-4010] p 169 N87-21585

Space Telescope Science Inst., Baltimore, Md.
A crisis in the NASA space and earth sciences programme p 112 A87-37998

Spar Aerospace Ltd., Ste-Anne-de-Bellevue (Quebec).
Optimization of aerospace structures subjected to random vibration and fatigue constraints
p 29 N87-20589

Spar Aerospace Ltd., Weston (Ontario).
Modal testing of the Olympus development model stowed solar array p 27 N87-20588

Spectrolab, Inc., Sylmar, Calif.
Design study of large area 8 cm x 8 cm wrapthrough cells for space station p 80 N87-26424

Sperry Space Systems, Durham, N.C.
Common drive unit p 104 N87-29009

SRI International Corp., Menlo Park, Calif.
Spacecraft dielectric material properties and spacecraft charging p 105 A87-33100

Stanford Univ., Calif.
A crisis in the NASA space and earth sciences programme p 112 A87-37998

State Univ. of New York, Buffalo.
Vibration suppression using a constrained rate-feedback Threshold control strategy
[AIAA PAPER 87-0741] p 6 A87-33666

Sterling Software, Palo Alto, Calif.
Synergetic plane-change capability of a conceptual aeromaneuvering-orbital-transfer vehicle
[AIAA PAPER 87-2565] p 92 A87-49915

Stevens Inst. of Tech., Hoboken, N.J.
Integration of communications and tracking data processing simulation for space station
p 115 N87-25007

Sverdrup Technology, Inc., Middleburg Heights, Ohio.
Microgravity fluid management requirements of advanced solar dynamic power systems
p 77 N87-21153

Sverdrup Technology, Inc., Cleveland, Ohio.
Composite space antenna structures - Properties and environmental effects p 20 A87-39910

Sydney Univ. (Australia).
Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 136 A87-43090

Systems Engineering Labs., Inc., Greenbelt, Md.
Modeling and control of flexible structures
[AD-A177100] p 29 N87-21388
Spectral factorization and homogenization methods for modeling and control of flexible structures
[AD-A179729] p 35 N87-24517

Systems Science and Software, La Jolla, Calif.
Theory of plasma contactors for electrodynamic tethered satellite systems p 98 A87-41609
Documentation for the SHADO particle wake routine
[AD-A181521] p 131 N87-28807

T

Technische Hochschule, Darmstadt (West Germany).
Active vibration damping of flexible structures using the travelling wave approach p 71 N87-25380

Technische Hogeschool, Delft (Netherlands).
Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2318] p 79 N87-24533
Maximum likelihood parameter identification of flexible spacecraft
[ETN-87-90226] p 38 N87-27705

Technische Univ., Berlin (West Germany).
Preliminary analysis of a prototype space solar power system
[ILR-MITT-168] p 79 N87-24532

Technische Univ., Munich (West Germany).
Micrometeorite exposure of solar arrays
p 62 N87-29062

Technology, Inc., Houston, Tex.
Space Station Food System
[SAE PAPER 860930] p 48 A87-38720

Telespazio, S.p.A., Rome (Italy).
Thermal-electrical dynamical simulation of spacecraft solar array p 63 N87-29004

Tennessee Univ. Space Inst., Tullahoma.
A general method for dynamic analysis of structures overview p 31 N87-22707

Texas A&M Univ., College Station.
Determination of the cross-sectional temperature distribution and boiling limitation of a heat pipe
p 40 A87-32175
Dynamic response of a viscoelastic Timoshenko beam
[AIAA PAPER 87-0890] p 16 A87-33709
Robust eigensystem assignment for flexible structures
[AIAA PAPER 87-2252] p 23 A87-50416
A quasi-analytical method for non-iterative computation of nonlinear controls p 69 N87-22731
Electrochemical processing of solid waste
[NASA-CR-181128] p 137 N87-25443
Active vibration control in microgravity environment
p 72 N87-26700
Regenerative fuel cells for space applications
p 84 N87-29039

Texas Univ., Austin.
Lanczos modes for reduced-order control of flexible structures p 33 N87-22739
The undersea habitat as a space station analog: Evaluation of research and training potential
[NASA-CR-180342] p 53 N87-27405

Tokyo Univ. (Japan).
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33810

Toronto Univ. (Ontario).
Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-26652

Toshiba Corp., Kanagawa (Japan).
The design and development of a two-dimensional adaptive truss structure p 40 N87-29020

TRW Space Technology Labs., Redondo Beach, Calif.
Spacecraft environment interaction investigation
[AD-A179180] p 140 N87-23679
Application of physical parameter identification to finite-element models p 34 N87-24505

U

Umpqua Research Co., Myrtle Creek, Ore.
Pre- and post-treatment techniques for spacecraft water recovery
[SAE PAPER 860982] p 50 A87-38761
Air Evaporation closed cycle water recovery technology - Advanced energy saving designs
[SAE PAPER 860987] p 51 A87-38766

United Technologies Corp., East Hartford, Conn.
The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986 p 2 A87-53002

United Technologies Corp., Windsor Locks, Conn.
Regenerable non-venting thermal control subsystem for extravehicular activity
[SAE PAPER 860947] p 42 A87-38734

University Coll. of North Wales, Bangor.
A microgravity isolation mount p 161 N87-26891

University of Southern California, Los Angeles.
Evaluation of on-line pulse control for vibration suppression in flexible spacecraft
[NASA-CR-180591] p 70 N87-24613

V

Vanderbilt Univ., Nashville, Tenn.
The role of electronic mechanisms in surface erosion and glow phenomena p 137 N87-26181
The production of low-energy neutral oxygen beams by grazing-incidence neutralization p 131 N87-26191

Vigyan Research Associates, Inc., Hampton, Va.
Effects of varying environmental parameters on trace contaminant concentrations in the NASA Space Station Reference Configuration
[SAE PAPER 860916] p 47 A87-38708
Supercritical water oxidation - Concept analysis for evolutionary Space Station application
[SAE PAPER 860993] p 51 A87-38770
A simulation model for the analysis of Space Station gas-phase trace contaminants p 52 A87-53879

Virginia Polytechnic Inst. and State Univ., Blacksburg.
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-33810
Spillover stabilization and decentralized modal control of large space structures
[AIAA PAPER 87-0903] p 17 A87-33712
A comparison of active vibration control techniques - Output feedback vs optimal control
[AIAA PAPER 87-0904] p 56 A87-33713
Accuracy of derivatives of control performance using a reduced structural model
[AIAA PAPER 87-0905] p 57 A87-33714
An approach to structure/control simultaneous optimization for large flexible spacecraft
p 22 A87-46780
An analytical and experimental investigation of output feedback vs. linear quadratic regulator
[AIAA PAPER 87-2389] p 61 A87-50474
Equations of motion for maneuvering flexible spacecraft p 62 A87-52666
Modeling and control of flexible structures
p 29 N87-20584
Maneuvering and vibration control of flexible spacecraft p 67 N87-22734
Some problems in the control of large space structures
[AD-A179669] p 75 N87-25380
An investigation of methodology for the control and failure identification of flexible structures
p 38 N87-26621
The effect of nonlinearities on flexible structures
[AD-A181736] p 39 N87-27259
Aromatic polyester polysiloxane block copolymers: Multiphase transparent damping materials
[AD-A182523] p 115 N87-27809
Modeling and computational algorithms for parameter estimation and optimal control of aeroelastic systems and large flexible structures
[AD-A183302] p 11 N87-29680

Virginia Univ., Charlottesville.
Theory and application of linear servo dampers for large scale space structures p 72 N87-26670
Digital control system for space structure dampers
[NASA-CR-181252] p 72 N87-27764

W

Washington State Univ., Pullman.
Aeroassisted orbital maneuvering using Lyapunov optimal feedback control
[AIAA PAPER 87-2484] p 93 A87-50609

Washington Univ., Seattle.
Radiation heat transfer calculations for space structures
[AIAA PAPER 87-1522] p 44 A87-44830

Washington Univ., St. Louis, Mo.
Temperature fields due to jet induced mixing in a typical OTV tank
[AIAA PAPER 87-2017] p 83 A87-52247
Numerical modeling of cryogenic propellant behavior in low-G p 85 N87-21148

WEA, Cambridge, Mass.
Wave mode coordinates and scattering matrices for wave propagation
[AD-A176869] p 29 N87-21030
Comparison of wave-mode coordinate and pulse summation methods
[AD-A177795] p 30 N87-21092
Wave propagation in transversely isotropic continuum models of LSS (Large Space Structures)
[AD-A177271] p 30 N87-22256

Whitmore Enterprises, San Antonio, Tex.
An improved waste collection system for space flight
[SAE PAPER 861014] p 119 A87-38784

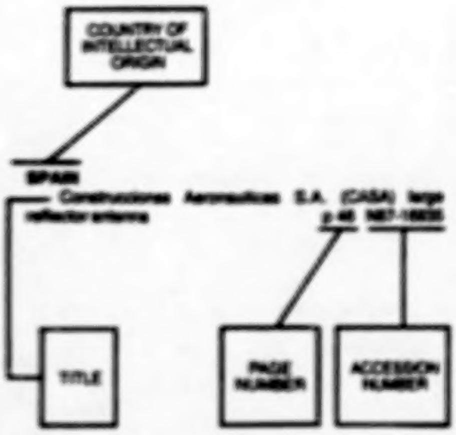
Y

Yale Univ., New Haven, Conn.
Product energy distributions and energy partitioning in O atom reactions on surfaces p 128 N87-26180
York Univ., Toronto (Ontario).
Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved p 142 N87-26049

267

FOREIGN TECHNOLOGY INDEX

Typical Foreign Technology Index Listing


COUNTRY OF INTELLECTUAL ORIGIN
SPAIN
Construcciones Aeronauticas S.A. (CASA) large reflector antenna p 46 N87-15820
TITLE
PAGE NUMBER
ACCESSION NUMBER

Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section.

A

AUSTRALIA

Adaptive tracking of dynamical model by uncertain nonlinear/rotatable spacecraft
[AIAA PAPER 87-0940] p 57 A87-33736

Nonequilibrium radiation during re-entry at 10 km/s
[AIAA PAPER 87-1543] p 135 A87-43086

B

BELGIUM

Solid Earth panel report p 157 N87-20806

C

CANADA

Space structure vibration modes - How many exist? Which ones are important? p 11 A87-32120

The Canadian space program p 143 A87-32281

Transient dynamics of orbiting flexible structural members p 54 A87-32356

Effect of long-term exposure to LEO space environment on spacecraft materials p 105 A87-39436

Deployment dynamics of space structures p 58 A87-40074

The Canadian Robotic System for the Space Station
[AIAA PAPER 87-1677] p 109 A87-41153

A formulation for studying dynamics of N connected flexible deployable members p 21 A87-41574

Evaluation of the infrared test method for the Olympus thermal balance tests p 44 A87-46692

Dynamics of gyroelastic spacecraft p 59 A87-47811

Global treatment of energy dissipation effects for multibody satellites p 62 A87-51616

Model reference adaptive control for large structural systems p 65 A87-52673

Modal testing of the Olympus development model stowed solar array p 27 N87-20089

Use of a video-photogrammetry system for the measurement of the dynamic responses of the shuttle remote manipulator arm p 101 N87-20370

Optimization of aerospace structures subjected to random vibration and fatigue constraints p 29 N87-23389

A formulation for studying steady state/transient dynamics of a large class of spacecraft and its application p 35 N87-25267

Spacecraft charging in the auroral plasma: Progress toward understanding the physical effects involved p 142 N87-26946

Arc propagation, emission and damage on spacecraft dielectrics p 143 N87-26952

CHINA, PEOPLE'S REPUBLIC OF

Dynamics of a multibody system with relative translation on curved, flexible tracks p 58 A87-40667

F

FINLAND

Design of a beacon receiving system for the Olympus satellite p 69 A87-50157

FRANCE

ERATO orbital transfer vehicle with electronuclear power. Study of the associated electronuclear generator p 75 A87-29844

The Signe II gamma-ray burst experiment aboard the Prognoz 9 satellite p 150 A87-39443

Physiological requirements and pressure control of a spacesuit
[SAE PAPER 860886] p 150 A87-39747

PEEK (Polyether ether ketone) with 30 percent of carbon fibres for injection molding p 22 A87-44508

Ariane transfer vehicle (ATV) to supply Space Station
[AIAA PAPER 87-1882] p 152 A87-45257

Analysis and implementation of automation aspects in the Columbus and Hermes end to end systems
[AIAA PAPER 87-2210] p 154 A87-48595

The astronaut and the robot - Short- and long-term scenarios for space technology p 101 A87-53061

Mechanical Qualification of Large Flexible Spacecraft Structures
[AD-A178626] p 26 N87-20058

Dynamic modeling and optimal control design for large flexible space structures p 26 N87-20066

Qualification of the faint object camera p 127 N87-20309

Dynamic analysis of direct television satellite TV-SAT/TDF-1 p 66 N87-20360

Low frequency vibration testing on satellites p 27 N87-20364

Proceedings of the European Symposium on Polar platform Opportunities and Instrumentation for Remote-Sensing (ESPOIR)
[ESA-SP-258] p 128 N87-20521

The Columbus program: An overview p 154 N87-20523

Remote sensing applications: Commercial issues and opportunities for space station p 156 N87-20525

Servicing of the polar platform p 129 N87-20526

USA-Europe coordination and cooperation activities: Announcements of Opportunity p 170 N87-20532

Panel report on multidisciplinary instrumentation: New possibilities p 161 N87-20807

Panel report on new approaches to calibration and validation p 157 N87-20808

Assessment of space station power system
[ATES-AN-86/480] p 79 N87-24530

Proceedings of the Second International Symposium on Spacecraft Flight Dynamics
[ESA-SP-255] p 171 N87-25354

Study of expert system applications to space projects
[NE-51-6057] p 115 N87-25557

The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications
[AGARD-CP-406] p 142 N87-26937

On the possibility of a several-kilovolt differential charge in the day sector of a geosynchronous orbit p 155 N87-26953

Study of data management system architecture options for space station
[MATRA-RF/176/0822-/0S-1] p 115 N87-28385

Proceedings of the Fifth European Symposium on Photovoltaic Generators in Space
[ESA-SP-267] p 81 N87-29859

The high performance solar array GSR3 p 81 N87-29872

MARECS and ECS anomalies: Attempt at insulation defect production in Kapton p 82 N87-29890

SPOT solar array in-orbit deployment results evaluation p 83 N87-29898

Aerospatiale solar arrays, in orbit performance p 159 N87-29899

Computer simulation of deployment p 10 N87-29902

SPOT/MEGS design and flight results obtained p 103 N87-29909

Experiences of CNES and SEP on space mechanisms rotating at low speed p 104 N87-29908

G

GERMANY, FEDERAL REPUBLIC OF

Highlights of the German Space Programme p 143 A87-32282

Space launcher upper stages - Design for mission versatility and/or orbital operation p 132 A87-32474

Demands imposed on a surface tension propellant tank due to refuelability in the microgravity environment of outer space
[DGLR PAPER 86-104] p 68 A87-36738

Intelligent flywheel energy storage units with additional functions for future space stations in near-earth orbits
[DGLR PAPER 86-172] p 67 A87-36792

Flunking on Space Station cooperation? p 150 A87-37934

Status of the RITA - Experiment on EURECA
[AIAA PAPER 87-0989] p 125 A87-38802

Analysis of crew functions as an aid in Space Station interior layout
[SAE PAPER 860934] p 163 A87-39734

The capabilities of Eureca thermal control for future mission scenarios
[SAE PAPER 860938] p 42 A87-39735

System aspects of Columbus thermal control
[SAE PAPER 860939] p 150 A87-39737

Columbus Life Support System and its technology development
[SAE PAPER 860966] p 150 A87-39746

Life Support Subsystem concepts for botanical experiments of long duration
[SAE PAPER 860967] p 49 A87-39748

Europe prepares for manned orbital operations p 151 A87-39894

The industrial use of Spacelab p 149 A87-40288

The Space Station - Uses and users p 151 A87-40913

Thoughts on Europe's future in space p 151 A87-41219

Carbon fibre slotted waveguide arrays p 66 A87-41502

The single-stage reusable ballistic launcher concept for economic cargo transportation p 136 A87-41573

Dynamic behavior of astronauts and satellites outside an orbiting space station under the influence of thrust p 52 A87-41688

Status and tendencies for low to medium thrust propulsion systems
[IAF PAPER 86-182] p 90 A87-42880

Control of an autonomous spacecraft rendezvous and docking maneuver by means of image processing
[DGLR PAPER 86-122] p 101 A87-42159

The problem of radiation exposure in the Space Station
[DGLR PAPER 86-175] p 153 A87-48137

Scientific user requirements for microgravity research of pressure aspects
[AIAA PAPER 87-2185] p 153 A87-48591

Automated software production
[AIAA PAPER 87-2216] p 2 A87-48601

Evolution of data management systems from Spacelab to Columbus
[AIAA PAPER 87-2227] p 154 A87-49805
Radiation protection problems for the Space Station and approaches to their mitigation p 154 A87-49830
Life support subsystem concepts for botanical experiments of long duration
[MBB-UR-E-907-86-PUB] p 154 A87-49867
An advanced wind scatterometer for the Columbus Polar Platform payload p 155 A87-52117
"HEXE" - X-ray observatory in space p 155 A87-52558
The GDR and the Soviet space program - The optical instrument sector of the GDR contributions p 155 A87-52559
Power plants in space p 155 A87-52580
Recent developments and future trends in structural dynamic design verification and qualification of large flexible spacecraft p 156 N87-20357
Dynamic qualification of spacecraft by means of modal synthesis p 26 N87-20363
Modal-survey testing for system identification and dynamic qualification of spacecraft structures p 27 N87-20365
Spacecraft qualification using advanced vibration and modal testing techniques p 27 N87-20368
Multi-axis vibration tests on spacecraft using hydraulic exciters p 8 N87-20373
European utilization aspects studies p 156 N87-20824
Land panel report p 129 N87-20834
Stress and deformation analysis of lightweight composite structures
[MBB-UD-499/86] p 30 N87-22269
Investigation for damping design and related nonlinear vibrations of spacecraft structures
[EMSB-64/86] p 30 N87-24516
Preliminary analysis of a prototype space solar power system
[ILR-MITT-188] p 79 N87-24532
Botanical payloads for platforms and space stations
[MBB-UR-E-921/86] p 156 N87-25340
Active vibration damping of flexible structures using the traveling wave approach p 71 N87-25380
Possibilities of the further development of Columbus to an autonomous European space station
[MBB-UR-E-922/86] p 158 N87-25418
Fiber composites in satellites
[MBB-UD-482/86] p 107 N87-25430
The Reinforced Modular Opto-electronic Multispectral Scanner (R-MOMS): A potential candidate for the Polar Orbiting Platform (POP) also
[MBB-UR-873/86] p 130 N87-25538
A study of fluid transfer management in space
[FTMS-RPT-006] p 87 N87-26058
Development of experimental/analytical concepts for structural design verification
[ESA-CR(P)-2340] p 38 N87-26075
The evolution of a serviceable EURECA
[MBB-UR-E-923/86] p 121 N87-26841
Control engineering tasks in the framework of the Columbus program
[MBB-UR-E-912/86] p 158 N87-26842
Preliminary study of a Biological and Biochemical Analysis Facility (BBAF) for Columbus: Executive summary
[ESA-CR(P)-2336] p 158 N87-27699
Study on investigation of the attitude control of large flexible spacecraft. Phase 1, volume 1: Technical report
[ESA-CR(P)-2361-VOL-1] p 73 N87-27706
Study on investigation of the attitude control of large flexible spacecraft. Phase 2, volume 1: Executive summary
[ESA-CR(P)-2361-VOL-1] p 73 N87-27707
Study on the investigation of the attitude control of large flexible spacecraft. Phase 2, volume 2: Technical report
[ESA-CR(P)-2361-VOL-2] p 73 N87-27708
Study on investigation of the attitude control of large flexible spacecraft, phase 3
[ESA-CR(P)-2361-VOL-4] p 73 N87-27709
AMOC: An alternative module configuration for advanced solar arrays in low Earth orbits p 159 N87-28069
Improved solar generator technology for the EURECA low Earth orbit p 159 N87-28074
Micrometeorite impact on solar panels p 82 N87-28081
Micrometeorite exposure of solar arrays p 82 N87-28082
The extendable and retractable mast as supporting tool for rigid solar arrays p 39 N87-28092
Absolute indoor calibration of large area solar cells p 159 N87-28095

I

INDIA
Stability of time varying linear systems p 7 A87-37135
A basis change strategy for the reduced gradient method and the optimum design of large structures p 23 A87-46241
Dynamics of an actively controlled flexible Earth observation satellite p 71 N87-25358
Design and fabrication of Stretched Rohini Satellite-1 solar array p 83 N87-29008
INTERNATIONAL ORGANIZATION
Europe's future in space p 143 A87-32278
Enhancement of solar absorptance degradation due to contamination of solar radiator panels in geosynchronous orbit - Correlation of flight data and laboratory measurements p 144 A87-32348
Space Station - Overview of the European concept of Columbus programme status and content p 145 A87-32526
Eureca - A first step towards the Space Station p 146 A87-32527
The European space programme p 150 A87-37962
Modal-survey testing of the Olympus spacecraft p 152 A87-42268
A model for the estimation of the operations and utilization costs of an international space station p 169 A87-42367
Materials for space applications p 106 A87-44741
ESA's future integrated space data system
[AIAA PAPER 87-2180] p 153 A87-48578
ESA software engineering standards for future programmes
[AIAA PAPER 87-2207] p 154 A87-49802
Comparison of different attitude control schemes for large communications satellites
[AIAA PAPER 87-2591] p 81 A87-50475
Microgravity experiments onboard Eureca p 155 A87-52554
From Eureca-A to Eureca-B p 155 A87-52916
The Columbus system baseline and interfaces p 156 A87-53623
Cooperation between Europe and the United States in space (The Fulbright 40th Anniversary Lecture) p 170 A87-53624
ITALY
On the dynamical stability of the space 'monorail' p 148 A87-34347
Advances by the Soviet Union in space cooperation and commercial marketing made 1986 a landmark year p 149 A87-34385
Tether system and controlled gravity
[AAS PAPER 86-248] p 124 A87-38673
Infrared test technique validation on the Olympus satellite
[SAE PAPER 860938] p 150 A87-38729
The Tethered Satellite System as a new remote sensing platform p 124 A87-39163
Non-intrusive techniques for thermal measurements in microgravity fluid science experiments p 151 A87-39836
Columbus pressurized modules p 153 A87-46948
Evaluation of the built-in stresses and residual distortions on cured composites for space antenna reflectors applications p 22 A87-47327
The hardware/software architecture of the Columbus pressurized module element
[AIAA PAPER 87-2211] p 154 A87-49808
The tethered satellite system for low density aerothermodynamics studies p 127 A87-52450
Effect of modal damping in modal synthesis of spacecraft structures p 26 N87-20362
Active structural controllers emulating structural elements by KOLs p 27 N87-20367
Payload data management scheme planned for Earth observation sensors to be flown on the polar platforms in the framework of the space station/Columbus program p 114 N87-20830
Data management panel report p 114 N87-20839
Attitude and Orientation System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Architecture of the whole simulation, volume 2
[LP-RP-AI-204-VOL-2] p 69 N87-24480
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Simulation set-up and results, volume 3
[LP-RP-AI-204-VOL-3] p 69 N87-24481
Attitude and Orientation Control System (AOCS) tasks on Rendezvous and Docking (RVD) (docking-undocking phases). Docking-undocking phase analysis
[LP-RP-AI-204-VOL-1] p 70 N87-24514
The Columbus program p 157 N87-25031
Simplified nonlinear control for large angle maneuvers of flexible spacecraft p 71 N87-25359
Automatic docking maneuver and attitude control system p 71 N87-25365
Data management system architecture options for space stations
[SES/DMP/TR/002/85] p 115 N87-26565
Rendezvous and docking (RVD) long range RF sensor definition study, executive summary
[SES/EHG/ES-516/86] p 139 N87-26598
Advanced Solar GaAs Array (ASGA) experiment on EURECA: Flight objectives and instrument configuration p 83 N87-28088
Organic Rankine cycle power conversion systems for space applications p 159 N87-28099
Thermal-electrical dynamical simulation of spacecraft solar array p 83 N87-29024

J

JAPAN
International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volumes 1 & 2 p 168 A87-32276
Japanese space program p 143 A87-32285
Prediction of random vibrational responses of a large spacecraft in acoustic environment by SLPF method p 144 A87-32334
Structural design and component tests of large geostationary satellite bus p 144 A87-32335
Model study of simplex masts p 144 A87-32339
Design consideration of mechanical and deployment properties of a coilable lattice mast p 12 A87-32340
Deployable surface truss concepts and two-dimensional adaptive structures p 144 A87-32341
Development of graphite epoxy space structure p 105 A87-32342
Thermal verification method for large sized spacecraft p 144 A87-32368
A thermally-pumped heat transport system p 40 A87-32369
Development of fluid loop system for spacecraft p 144 A87-32370
Laboratory simulation of plasma interaction with high voltage solar array p 145 A87-32399
Thermal deformation and electrical degradation of antenna reflector with truss backstructure p 12 A87-32435
Local control for large space structures p 54 A87-32440
A consideration to vibration control for a large space structure p 54 A87-32441
Flexibility control of torsional vibrations of a large solar array p 12 A87-32442
Two-time-scale design of robust controllers for large structure systems p 12 A87-32443
Vibration control for a linked system of flexible structures p 55 A87-32444
Precise pointing control of flexible spacecraft p 55 A87-32445
A preliminary study on a linear inertial actuator for LSS control p 56 A87-32447
Control of flexible solar arrays with consideration of the actuator dynamics of the reaction wheel p 55 A87-32448
Control of a flexible space manipulator p 56 A87-32449
Preliminary experimental study on the oxygen separating and concentrating system for CELSS p 45 A87-32455
Development of carbon dioxide removal system - Experimental study of solid amines p 145 A87-32456
Gas and water recycling system for IOC vivarium experiments p 45 A87-32457
Water recycling system using thermopervaporation method p 46 A87-32458
Water recycling for Space Station p 46 A87-32459
System and operation analyses of OTV Network - A new space transportation concept p 145 A87-32475
Observation of precipitation from space by the weather radar p 145 A87-32507
Preliminary results of CHARGE-2 tethered payload experiment p 121 A87-32521
Space Station program in a long-range space development scenario of Japan p 145 A87-32530
Status of Japanese Experiment Module design p 145 A87-32531
Development of exposed deck of Japanese experiment module p 145 A87-32532
On the payload-tether technology providing the microgravity circumstances in the proximity of the Space Station p 122 A87-32533
An enclosed hangar concept for large spacecraft servicing at Space Station p 146 A87-32534
Solar concentrator system for experiments in the Space Station p 146 A87-32535
Advanced technology experiment onboard space platform p 122 A87-32536

Concept design and cost estimation of a free-flying space platform p 146 A87-22539
Payload boomerang technology for space experiments at very low gravity level p 146 A87-22540
Autonomous decentralized system concept for Space Station p 146 A87-22541
Japanese experiment module data management and communication system p 147 A87-22542
Concept study of regenerable carbon dioxide removal and oxygen recovery system for the Space Station p 46 A87-22544
Study of actuator for large space manipulator arm p 12 A87-22545
A master-slave manipulator system for space use p 147 A87-22546
Development of sensors for remote manipulator system of Japanese Experiment Module p 147 A87-22547
Structure and function of Deployable Truss Beam (DTB) p 12 A87-22548
Evaluation testing of a mechanical actuator component operating in a simulated space environment p 160 A87-22549
Simultaneous structure/control optimization of large flexible spacecraft
[AIAA PAPER 87-0823] p 14 A87-22810
New concepts of deployable truss units for large space structures
[AIAA PAPER 87-0828] p 14 A87-22832
Adaptive planar truss structures and their vibration characteristics
[AIAA PAPER 87-0743] p 146 A87-22867
Alternative methods to fold/deploy tetrahedral or pentahedral truss platforms p 19 A87-24457
Communication missions for geostationary platforms p 84 A87-24787
Development of harmonic drive actuator for space manipulator p 149 A87-26076
A study on singularity of single gimbal CMG systems p 149 A87-26077
Automatic generation of stochastically dominant failure modes for large-scale structures p 149 A87-27653
Development of the electrical power subsystem for the electric propulsion experiment onboard the Space Flyer Unit (SFU)
[AIAA PAPER 87-1040] p 76 A87-36828
Development of control and monitor subsystem for electric propulsion experiment onboard Space Flyer Unit (SFU)
[AIAA PAPER 87-1041] p 76 A87-36829
Japanese Experiment Module (JEM) preliminary design status p 151 A87-41575
Japan's space development programs for communications - An overview p 152 A87-43156
On-board K- and S-band multi-beam antennas p 88 A87-43261
Japanese space information system overview
[AIAA PAPER 87-2181] p 153 A87-46579
Japanese customer needs for Space Station
[AIAA PAPER 87-2183] p 153 A87-46580
Japanese data relay satellite system
[AIAA PAPER 87-2189] p 154 A87-46586
Mission scheduling expert system and its space station applications
[AIAA PAPER 87-2221] p 7 A87-46602
Modeling and control of torsional vibrations in a flexible structure p 90 A87-50020
Low-authority control of large space structures by using tendon control system
[AIAA PAPER 87-2346] p 80 A87-50413
The intuition function control for deployment and retrieval of subsatellite
[AIAA PAPER 87-2526] p 128 A87-50447
Development of metal matrix composites in R & D Institute of Metals & Composites for Future Industries p 107 A87-51772
Development of full scale deployable CFRP truss for space structure p 25 A87-51785
Tailored laminates with null or arbitrary coefficient of thermal expansion p 107 A87-51794
Development of a small-sized space manipulator p 151 A87-51879
The design and development of a two-dimensional adaptive truss structure p 40 N87-25000

N

NETHERLANDS
Living in space: A handbook for space travellers p 160 A87-33475
Quality monitoring in two-phase heat transport systems for large spacecraft
[SAE PAPER 860955] p 42 A87-38743
Survey of solar-dynamic space power - The Stirling option p 77 A87-42885
Acoustic effects on the dynamic of lightweight structures p 29 N87-20572
The Earth observation activities of the European Space Agency and the use of the polar platform of the International Space Station p 128 N87-20622
Working group on Earth observation requirements for the Polar Orbiting Platform Elements of the International Space Station (the POPE Working Group) p 128 N87-20625
ESA Columbus polar platform design concept p 156 N87-20627
Orbit configurations p 156 N87-20629
Cooperation of the International Space Station partners in the preparation of the use of space station elements for Earth observation (platform and payload aspects) p 128 N87-20631
The orbit configuration panel report p 157 N87-20640
Panel report on the polar platform servicing approach and its implications p 136 N87-20641
End effector development study. Volume 2: Service End Effector subsystem specification (SEESSPEC)
[FOK-TR-R-86-091-VOL-2] p 102 N87-24486
Status of series-resonant power conversion with high internal frequencies. Support in definition of space station power interface
[ESA-CR(P)-2316] p 79 N87-24533
End effector development study, volume 1
[FOK-TR-R-86-091-VOL-1] p 102 N87-25336
End effector development study. Volume 3: Appendices
[FOK-TR-R-86-091-VOL-3] p 102 N87-25337
Electrostatic immunity of geostationary satellites p 143 N87-26667
Maximum likelihood parameter identification of flexible spacecraft
[ETN-87-90236] p 38 N87-27735
Summary of recent SAR instrument studies p 159 N87-27886
EURECA application of the Retractable Advanced Rigid Array (RARA) solar array p 82 N87-28873
The INMARSAT solar array: The first Advanced Rigid Array (ARA) to fly p 82 N87-28875
High power solar array technologies p 82 N87-28876
The Fokker Stronglink solar array p 82 N87-28879
Stepping differential charging of solar arrays p 83 N87-28884
Space 2000 in Europe p 159 N87-29024

R

ROMANIA (RUMANIA)
Permanent-magnet linear alternators. I - Fundamental equations. II - Design guidelines p 76 A87-38735

S

SPAIN
Service Manipulator Arm (SMA) for a Robotic Servicing Experiment (ROSE)
[ESA-CR(P)-2347] p 103 N87-29280

T

TAIWAN
New time-domain identification technique p 59 A87-45999
Orbital debris environment resulting from future activities in space p 139 A87-44392

U

U.S.S.R.
Gravity-gradient stabilization of the Salyut 6-Soyuz orbital complex p 147 A87-32901
Stability in the relative equilibrium positions of space stations at triangular libration points in the photogravitational three-body problem p 1 A87-32903
Contribution of the German Democratic Republic (East Germany) to the 'Intercosmos' program of study of materials in space aboard the orbiting station Salyut 6 p 147 A87-32914
Instability of an elastic filament in orbit around a gravitating center p 148 A87-32915
Critical length for stable elongated orbiting structures p 148 A87-32916
Choice of the optimal angular position of a spacecraft in the constant-solar-orientation flight segment p 148 A87-34207
Optimization of a program of experiments in connection with the operational planning of studies carried out with a spacecraft p 148 A87-34208
Shape control of the directional pattern in a microwave-beam power transmission channel p 148 A87-34345
The synthesis of the power transmission channel for a satellite solar power station p 75 A87-35799
Problems of mechanical system configuration control p 149 A87-35877
Legal problems concerning manned space flight p 151 A87-42339
K.E. Tsiolkovskii and problems in the development of science and technology p 151 A87-42342
Expected size of a crater resulting from the impact of a micrometeorite p 119 A87-41870
Effect of crew motions on the spatial position of a spacecraft p 152 A87-41954
The Gagarin scientific lectures in astronautics and aviation, 1985 p 152 A87-42923
Solar power satellites p 152 A87-44883
Determination of the natural frequencies of the longitudinal and torsional vibrations of truss structures with attached rigid bodies p 152 A87-46121
The Gagarin Scientific Lectures on Astronautics and Aviation, 1986 p 160 A87-51869
Structure and design of spacecraft p 155 A87-51870
Space biology and medicine on the twenty-fifth anniversary of the first spaceflight of Yuriy Alekseyevich Gagarin p 157 N87-20732
Evaluation of physical work capacity of cosmonauts aboard Salyut-6 station p 157 N87-20735
Status of orbital astronomy projects p 128 N87-21673
Plans for industrialization of space discussed p 157 N87-21679
USSR Report: Space
[JPRS-USP-86-004] p 158 N87-27667
Pravda commentary, photos of Mir orbital station p 158 N87-27669
IKI department head on orbital power plants p 158 N87-27680
Progress in theory, technology of space materials science p 158 N87-27685
Optimizing experimental programs in operational planning of research carried out from spacecraft p 160 N87-28563

UNITED KINGDOM
British activities in space p 143 A87-32260
Design of a polar platform with an earth observation payload p 122 A87-32728
Space Station - Opportunities for the life sciences p 122 A87-34671
Mechanical design of the Eurostar platform p 149 A87-34674
The SERVICE concept p 134 A87-36362
Coded mask telescopes for X-ray astronomy p 123 A87-37798
Mir in action p 150 A87-37871
The use of electric propulsion on low earth orbit spacecraft
[AIAA PAPER 87-0988] p 88 A87-38003
A UK large diameter ion thruster for primary propulsion
[AIAA PAPER 87-1021] p 89 A87-38015
An evolutionary approach to the development of a CELSS based air revitalization system
[SAE PAPER 860968] p 46 A87-38750
Columbus/Space Station United Kingdom Utilisation Study 1985/6 Report - Executive Summary p 151 A87-41429
A polar platform for the remote sensing needs of ecology and agriculture - A view from the U.K. p 129 A87-41430
Space: New opportunities for all people; Selected Proceedings of the Thirty-seventh International Astronautical Congress, Innsbruck, Austria, Oct. 4-11, 1986 p 160 A87-41569
Attitude control of a spacecraft using an extended self-organizing fuzzy logic controller p 59 A87-41817
Space Station opportunity for UK in earth sensing p 152 A87-41876
The Soviet space shuttle programme p 153 A87-47302
Identification of large space structures - A factorization approach p 25 A87-52600
Ion thrusters advance p 93 A87-54186
Infra-red astronomy after IRAS p 127 A87-54187
Developing Space Station. II - Power, rendezvous, docking and remote sensing are important elements of the Space Station p 127 A87-54188
Influence co-efficient testing as a substitute for modal survey testing of large space structures p 27 N87-20569
Report of the atmosphere panel p 161 N87-20633
Ocean-ice panel report p 156 N87-20636
Ideas for extra-lunar physics experiments in space p 130 N87-25033

The use of Pi2 pulsations as indicators of substorm effects at geostationary orbit p 142 N87-25942

Radiation charging and breakdown of insulators p 143 N87-25954

Surface modification to minimise the electrostatic charging of Kapton in the space environment p 87 N87-25959

GaAs concentrator solar arrays p 82 N87-25977

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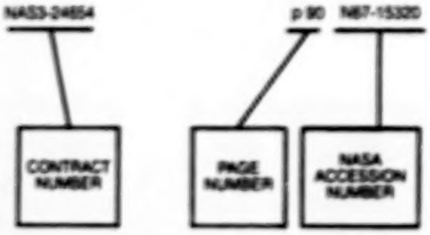
CONTRACT NUMBER INDEX

Typical Contract Number Index Listing



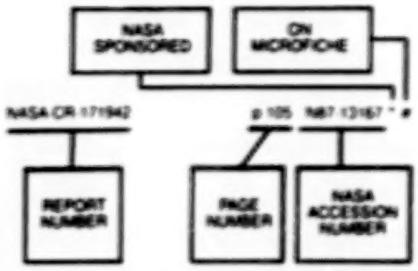
Listings in this index are arranged alpha-numerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the AIAA accession numbers appearing first. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

AF-AFOSR-0017-83 p 70 N87-25350
AF-AFOSR-0090-85 p 38 N87-27259
AF-AFOSR-0188-81 p 11 N87-30107
AF-AFOSR-0201-83 p 110 N87-27909
AF-AFOSR-0267-85 p 11 N87-29883
AF-AFOSR-0352-85 p 30 N87-22252
AF-AFOSR-0381-83 p 34 N87-23883
AF-AFOSR-82-0242 p 59 A87-42505
AF-AFOSR-83-0017 p 58 A87-33710
AF-AFOSR-83-0318 p 59 A87-46301
AF-AFOSR-84-0309 p 24 A87-50504
AF-AFOSR-85-0220 p 6 A87-33885
p 59 A87-42505
AF-AFOSR-85-0253 p 21 A87-41052
CDC-2457-38001-3-1888 p 21 A87-41052
ONR-PSN-84-048 p 127 A87-52450
ONR-PSN-85-082 p 127 A87-52450
DAAG29-78-C-0020 p 59 A87-46301
DAAG29-82-K-0084 p 61 A87-50503
DE-AC02-76CH-00016 p 99 N87-29405
DE-AC05-84OR-21400 p 101 N87-20774
p 101 N87-22231
p 102 N87-22233
p 102 N87-22242
p 69 N87-24026
p 100 N87-27408
p 74 N87-29833
DE-AI03-86SF-16013 p 79 N87-25838
ESA-1882/84-NL-AN p 102 N87-24488
p 102 N87-25336
p 102 N87-25337
ESA-4750/81-NL-AK(SC) p 69 N87-24490
p 69 N87-24491
p 70 N87-24514
ESA-5170/85-NL-AN(SC) p 79 N87-24530
p 79 N87-24533
ESA-6093/84-NL-GM(SC) p 139 N87-28569
ESA-6238/85-NL-AN p 82 N87-28882
ESA-6807/86-F-HEW p 158 N87-27888
ESTEC-5168/82-NL-PB(SC) p 35 N87-26075
ESTEC-5310/82-NL-BI p 73 N87-27706
p 73 N87-27707
p 73 N87-27708
p 73 N87-27709
ESTEC-5328/83-NL-PB(SC) p 35 N87-24518
ESTEC-5898/84-NL-PP(SC) p 115 N87-28566
ESTEC 5897/84-NL-PP(SC) p 115 N87-28565
ESTEC-6013/84-NL-PB(SC) p 97 N87-28056
ESTEC-6028/84-NL-JS p 115 N87-28057
ESTEC-6174/85-NL-AN(SC) p 100 N87-28280
F04701-82-C-83 p 67 N87-26881
F04701-85-C-0086-P00016 p 92 A87-45380
F04701-85-C-0086 p 138 A87-34480
p 140 N87-21024
p 110 N87-25709
F19628-83-K-0028 p 142 N87-26649
F19628-84-C-0036 p 140 N87-23878
F19698-85-C-0056 p 131 N87-26887
F29601-85-K-0054 p 31 N87-22707
F33615-82-C-3222 p 55 A87-32730
F33615-82-C-3226 p 58 A87-38644
F33615-83-C-3232 p 6 A87-33557
F33615-83-K-5089 p 110 N87-28584
F33615-84-C-3217 p 21 A87-40896
F33615-86-C-3233 p 60 A87-[illegible]
F49620-84-C-0036 p 61 A87-[illegible]72
F49620-84-C-0115 p 25 A87-50507
p 25 N87-21388
p 35 N87-24217
F49620-84-K-0010 p 72 N87-25805
F49620-85-C-0024 p 18 A87-33741
F49620-85-C-0148 p 25 N87-21030
p 30 N87-21882
p 30 N87-22258
F49620-86-C-0002 p 29 N87-21025
F49620-86-K-0014 p 14 A87-32591
F496820-83-C-0026 p 108 N87-28180
JPL-958415 p 54 A87-31881
JPL-957114 p 6 A87-32857
NAGW-21 p 108 A87-45797
NAGW-455 p 115 N87-24817
NAGW-659 p 157 N87-21888
NAGW-728 p 135 A87-43080
NAGW-812 p 108 N87-28177
NAGW-823 p 108 N87-28177
NAG1-126 p 37 N87-26366
NAG1-138 p 10 N87-27412
NAG1-215 p 37 N87-26370
NAG1-224 p 14 A87-33810
p 58 A87-33713
p 22 A87-46780
p 61 A87-50474
NAG1-225 p 63 A87-52995
p 67 N87-22734
NAG1-258 p 11 N87-30107
NAG1-349 p 72 N87-27704
NAG1-41 p 44 A87-44830
NAG1-436 p 58 A87-38958
p 62 A87-50561
NAG1-438 p 38 N87-27260
NAG1-541 p 39 N87-29590
NAG1-551 p 45 N87-26072
p 45 N87-26838
p 45 N87-27702
NAG1-600 p 17 A87-33712
p 57 A87-33714
NAG1-612 p 38 N87-26071
p 37 N87-26367
NAG1-613 p 62 A87-50561
NAG1-638 p 70 N87-24513
NAG1-655 p 24 A87-50471
p 38 N87-26583
NAG1-680 p 136 A87-46818
p 137 N87-26627
NAG1-729 p 40 N87-29686
NAG2-348 p 122 A87-35222
NAG3-578 p 93 A87-52247
NAG3-580 p 7 A87-35718
NAG3-620 p 129 N87-22508
p 142 N87-26646
NAG3-637 p 62 A87-52257
NAG3-695 p 125 A87-42[illegible]
NAG3-696 p 132 N87-29833
NAG5-520 p 34 N87-23880
p 38 N87-25805
p 74 N87-29713
p 40 N87-29686
NAG5-749 p 34 N87-23880
p 38 N87-25805
p 74 N87-29713
p 40 N87-29686
NAG5-780 p 100 A87-45797
NAG5-874 p 140 N87-23098
NAG8-521 p 109 N87-26200
NAG8-532 p 6 A87-33561
p 29 N87-20589
NAG8-582 p 141 N87-26082
p 53 N87-26086
NAG9-128 p 129 N87-22509
p 131 N87-29581
NAG9-140 p 16 A87-33708
NAG9-182 p 137 N87-25443
NASA ORDER L-76724-B p 120 N87-24182
NAS1-15810 p 11 N87-30107
NAS1-16394 p 11 N87-30107
NAS1-16810 p 8 N87-21020
NAS1-17210 p 10 N87-24709
NAS1-17389 p 60 A87-48273
NAS1-17536 p 66 N87-21894
NAS1-17660 p 7 A87-33728
NAS1-17918 p 47 A87-38708
p 51 A87-38770
p 52 A87-53979
NAS1-18013 p 35 N87-25349
NAS1-18016 p 30 N87-21887
NAS1-18032 p 9 N87-21895
NAS1-18229 p 38 N87-26808
NAS1-18267 p 120 N87-20340
NAS1-550 p 47 A87-38708
p 52 A87-53979
NAS2-11530 p 112 A87-42821
NAS2-11667 p 50 A87-38764
NAS2-11723 p 118 A87-33003
p 163 A87-38724
NAS3-23353 p 54 N87-29894
NAS3-23773 p 135 A87-41161
p 139 A87-48800
p 137 N87-26097
NAS3-23889 p 7 A87-41611
NAS3-23891 p 65 A87-41609
p 140 A87-51713
NAS3-23893 p 68 N87-26129
NAS3-24091 p 97 N87-24841
NAS3-24092 p 81 N87-26885
NAS3-24096 p 75 N87-23885
p 79 N87-23889
NAS5-2750 p 119 A87-46887
NAS5-29124 p 113 A87-46485
NAS5-29248 p 41 A87-32883
NAS5-29300 p 119 A87-38742
NAS7-918 p 11 A87-32239
p 15 A87-33024
p 15 A87-33888
p 16 A87-33752
p 22 A87-47812
p 79 N87-25838
p 141 N87-26173
NAS7-936 p 139 A87-38823
p 108 N87-28189
NAS8-31778 p 87 N87-26081
NAS8-33982 p 138 A87-34480
NAS8-35098 p 87 N87-26082
p 3 N87-26083
p 3 N87-26084
p 3 N87-26085
p 4 N87-26086
p 4 N87-26087
NAS8-35471 p 124 A87-38757
NAS8-35871 p 88 N87-26118
NAS8-36102 p 53 N87-26086
NAS8-36105 p 129 A87-44533
NAS8-36107 p 91 A87-45191
NAS8-36400 p 64 N87-20885
NAS8-36418 p 91 A87-45256
NAS8-36420 p 17 A87-33709
NAS8-36426 p 39 N87-29581
p 39 N87-29582
p 4 N87-29583
NAS8-36427 p 124 A87-38780
NAS8-36498 p 62 A87-50568
p 67 N87-22758
NAS8-36526 p 91 A87-45259
NAS8-36570 p 71 N87-25801
NAS8-36606 p 125 A87-40850
p 130 N87-26023
NAS8-36817 p 131 N87-29585
NAS8-4486 p 40 A87-32175

272

NAS9-15800 ______ p 165 N87-22744
p 137 N87-25339
NAS9-16895 ______ p 53 N87-29117
NAS9-17207 ______ p 138 N87-20335
NAS9-17299 ______ p 120 N87-20351
NAS9-17332 ______ p 85 A87-45483
NAS9-17471 ______ p 84 A87-31462
NAS9-17472 ______ p 85 A87-45519
NAS9-17560 ______ p 58 A87-37295
p 62 A87-50531
NAS9-17613 ______ p 81 N87-28198
NAS9-17900 ______ p 137 N87-25339
NCA2-181 ______ p 93 A87-50506
NCC2-210 ______ p 130 N87-25767
NCC2-298 ______ p 53 N87-27405
NCC2-356 ______ p 165 N87-21585
NERC-P80/G6/16 ______ p 125 A87-41430
NGT-01-008-021 ______ p 67 N87-22752
NGT-[illegible]43-801 ______ p 6 A87-33885
NSERC-A-4183 ______ p 11 A87-32120
p 59 A87-47811
NSERC-A-8730 ______ p 21 A87-41052
NSERC-G-1547 ______ p 21 A87-41574
p 35 N87-25367
NSERC-67-1547 ______ p 54 A87-32338
p 58 A87-40074
NSF CPE-81-14348 ______ p 108 N87-28180
NSF DMS-84-01297 ______ p 21 A87-41052
NSF ECS-83-14238 ______ p 76 A87-39735
NSF ECS-86-18445 ______ p 58 A87-38858
p 62 A87-50581
NSF INT-84-08315 ______ p 76 A87-39735
NSF MCS-82-00883 ______ p 11 N87-30107
NSF MCS-82-05355 ______ p 11 N87-30107
NSF MEA-83-51807 ______ p 6 A87-33885
p 59 A87-42505
NSG-1414 ______ p 12 A87-32337
p 72 N87-28038
p 73 N87-27712
NSG-1480 ______ p 58 A87-33573
N00014-84-C-0148 ______ p 58 A87-38858
N00014-86-C-2200 ______ p 140 N87-21891
PRF-17008-AC5-C ______ p 108 N87-28180
W-7405-ENG-48 ______ p 171 N87-22887
186-30-21 ______ p 128 N87-20841
p 129 N87-22570
p 129 N87-22571
199-13-46-1 ______ p 120 N87-24162
199-61-12 ______ p 130 N87-25767
199-99-00-00-72 ______ p 53 N87-27392
481-01-02 ______ p 97 N87-25422
481-02-02 ______ p 93 N87-20378
p 96 N87-24538
p 99 N87-28135
481-32-23-01 ______ p 65 N87-21894
481-51-02 ______ p 90 N87-28144
481-52-02 ______ p 107 N87-25480
481-54-02 ______ p 98 N87-22001
p 78 N87-22004
p 88 N87-23880
482-52-21 ______ p 165 N87-21585
482-53-53-38 ______ p 8 N87-21020
482-58-19-02 ______ p 117 N87-29167
483-31-03-01 ______ p 100 N87-29583
483-32-03-02 ______ p 140 N87-20795
485-40-02 ______ p 78 N87-23885
p 79 N87-23888
505-41-5A ______ p 44 N87-20353
505-63-11-01 ______ p 40 N87-29899
505-67-51 ______ p 171 N87-25780
506-00-00 ______ p 79 N87-25838
506-41-11 ______ p 78 N87-23026
506-41-21 ______ p 79 N87-24838
p 5 N87-29814
506-41-31 ______ p 95 N87-22003
p 78 N87-22174
506-42-31 ______ p 63 N87-20477
p 88 N87-22237
p 98 N87-23821
506-43-21-01 ______ p 141 N87-28173
506-43-41-02 ______ p 37 N87-28085
506-43-51-02 ______ p 28 N87-20567
p 10 N87-24709
506-43-51-04 ______ p 88 N87-20339
506-48-21 ______ p 95 N87-22948
506-49-21-01 ______ p 26 N87-20352
506-49-21 ______ p 45 N87-21021
506-49-22 ______ p 54 N87-29594
506-49-38 ______ p 165 N87-20342
p 94 N87-21141
506-49-31-01 ______ p 120 N87-20340
p 66 N87-23887
506-58-13 ______ p 116 N87-29148
506-58-23-01 ______ p 30 N87-21967
542-08-11-01 ______ p 34 N87-24485
546-01-31-01 ______ p 36 N87-25838
999-15-00-00-72 ______ p 103 N87-29858

Typical Report Number Index Listing



Listings in this index are arranged alpha-numerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A-86037	p 52	N87-24084 * #
A-87113	p 129	N87-22571 * #
A-87133	p 129	N87-20941 * #
A-87172	p 129	N87-22570 * #
A-87212	p 171	N87-25760 * #
AAC-TN-1150-REV-A	p 35	N87-25349 * #
AAS PAPER 86-001	p 55	A87-32727 *
AAS PAPER 86-003	p 13	A87-32729
AAS PAPER 86-004	p 55	A87-32730
AAS PAPER 86-007	p 56	A87-32732 *
AAS PAPER 86-014	p 133	A87-32733 *
AAS PAPER 86-031	p 56	A87-32739 *
AAS PAPER 86-036	p 56	A87-32741
AAS PAPER 86-041	p 133	A87-32743 *
AAS PAPER 86-042	p 133	A87-32744 *
AAS PAPER 86-043	p 89	A87-32745 *
AAS PAPER 86-044	p 89	A87-32746 *
AAS PAPER 86-050	p 75	A87-32747 *
AAS PAPER 86-103	p 170	A87-53083
AAS PAPER 86-108	p 170	A87-53085
AAS PAPER 86-109	p 2	A87-53086
AAS PAPER 86-114	p 165	A87-53089
AAS PAPER 86-208	p 123	A87-38568 *
AAS PAPER 86-210	p 89	A87-38569 *
AAS PAPER 86-221	p 123	A87-38570
AAS PAPER 86-227	p 123	A87-38571 *
AAS PAPER 86-229	p 89	A87-38572 *
AAS PAPER 86-240	p 124	A87-38573
AAS PAPER 86-244	p 124	A87-38574 *
ACSC-87-1425	p 171	N87-25815 #
AD-A175224	p 29	N87-20574 #
AD-A175529	p 28	N87-20355 #
AD-A176722	p 170	N87-21753 #
AD-A176815	p 140	N87-21024 #
AD-A176820	p 29	N87-21025 #
AD-A176868	p 29	N87-21030 #
AD-A177106	p 29	N87-21388 #
AD-A177169	p 30	N87-22252 #
AD-A177271	p 30	N87-22258 #
AD-A177512	p 140	N87-21981 #
AD-A177795	p 30	N87-21992 #
AD-A178576	p 65	N87-22675 #
AD-A178870	p 68	N87-22761 #
AD-A178897	p 120	N87-22762 #
AD-A179108	p 161	N87-23677 #
AD-A179183	p 140	N87-23679 #
AD-A179205	p 129	N87-22756 #
AD-A179230	p 3	N87-23680 #
AD-A179235	p 68	N87-23681 #
AD-A179241	p 137	N87-23682 #
AD-A179459	p 34	N87-23683 #
AD-A179711	p 72	N87-25805 #
AD-A179728	p 35	N87-24517 #
AD-A179873	p 171	N87-25815 #
AD-A179980	p 70	N87-25350 #
AD-A180275	p 130	N87-25351 #
AD-A180806	p 71	N87-25352 #
AD-A180821	p 172	N87-26864 #
AD-A181488	p 72	N87-26866 #
AD-A181531	p 131	N87-26867 #
AD-A181725	p 38	N87-27259 #
AD-A181798	p 103	N87-26899 #
AD-A181882	p 1	A87-40351
AD-A182589	p 81	N87-28186 #
AD-A182605	p 46	N87-28217 #
AD-A182623	p 110	N87-27809 #
AD-A182786	p 110	N87-28584 #
AD-A182931	p 110	N87-28739 #
AD-A183202	p 11	N87-29883 #
AD-A185880	p 142	N87-29837 #
AD-D012559	p 83	N87-20375
AFGL-TR-86-0214	p 140	N87-23678 #
AFGL-TR-87-0042	p 131	N87-26867 #
AFIT/CI/NR-87-18T	p 170	N87-21753 #
AFIT/GA/AA/86D-2	p 68	N87-23681 #
AFIT/GA/AA/86D-5	p 129	N87-22756 #
AFIT/GE/ENG/86D-41	p 68	N87-22761 #
AFIT/GE/ENG/87J-2	p 81	N87-28186 #
AFIT/GNE/ENP/87M-1	p 46	N87-28217 #
AFIT/GSO/AA/86D-2	p 161	N87-23677 #
AFIT/GSO/AA/86D-5	p 3	N87-23680 #
AFIT/GSO/ENG/86D-1	p 120	N87-22762 #
AFIT/GSO/ENS/86D-3	p 137	N87-23682 #
AFOSR-87-0013TR	p 29	N87-21388 #
AFOSR-87-0021TR	p 29	N87-21030 #
AFOSR-87-0161TR	p 29	N87-21025 #
AFOSR-87-0165TR	p 30	N87-22252 #
AFOSR-87-0176TR	p 110	N87-27809 #
AFOSR-87-0278TR	p 30	N87-22258 #
AFOSR-87-0280TR	p 30	N87-21992 #
AFOSR-87-0402TR	p 34	N87-23683 #
AFOSR-87-0426TR	p 70	N87-25350 #
AFOSR-87-0502TR	p 35	N87-24517 #
AFOSR-87-0560TR	p 72	N87-25805 #
AFOSR-87-0712TR	p 38	N87-27259 #
AFOSR-87-0956TR	p 11	N87-29883 #
AFWAL-TR-87-4010	p 110	N87-28584 #
AGARD-CP-397	p 28	N87-20355 #
AGARD-CP-408	p 142	N87-29837 #
AIAA PAPER 85-0387	p 7	A87-41611 * #
AIAA PAPER 87-0572	p 121	A87-32192 * #
AIAA PAPER 87-0710	p 15	A87-33558 * #
AIAA PAPER 87-0713	p 6	A87-33557 #
AIAA PAPER 87-0718	p 6	A87-33560 * #
AIAA PAPER 87-0720	p 6	A87-33561 * #
AIAA PAPER 87-0724	p 13	A87-33564 #
AIAA PAPER 87-0725	p 13	A87-33565 * #
AIAA PAPER 87-0741	p 6	A87-33566 * #
AIAA PAPER 87-0743	p 148	A87-33567 #
AIAA PAPER 87-0745	p 16	A87-33569 #
AIAA PAPER 87-0746	p 16	A87-33570 * #
AIAA PAPER 87-0749	p 58	A87-33573 * #
AIAA PAPER 87-0782	p 19	A87-33756 * #
AIAA PAPER 87-0784	p 16	A87-33579 #
AIAA PAPER 87-0787	p 13	A87-33580 #
AIAA PAPER 87-0791	p 14	A87-33581 #
AIAA PAPER 87-0818	p 19	A87-33757 #
AIAA PAPER 87-0821	p 122	A87-33587 #
AIAA PAPER 87-0823	p 14	A87-33610 * #
AIAA PAPER 87-0824	p 14	A87-33611 * #
AIAA PAPER 87-0826	p 14	A87-33613 * #
AIAA PAPER 87-0868	p 14	A87-33632 #
AIAA PAPER 87-0869	p 15	A87-33633 * #
AIAA PAPER 87-0870	p 15	A87-33634 * #
AIAA PAPER 87-0871	p 15	A87-33635 #
AIAA PAPER 87-0872	p 15	A87-33636 * #
AIAA PAPER 87-0877	p 105	A87-33638 #
AIAA PAPER 87-0887	p 16	A87-33705 * #
AIAA PAPER 87-0890	p 16	A87-33706 * #
AIAA PAPER 87-0891	p 55	A87-38644 #
AIAA PAPER 87-0892	p 17	A87-33709 * #
AIAA PAPER 87-0895	p 16	A87-33689 * #
AIAA PAPER 87-0900	p 56	A87-33710 #
AIAA PAPER 87-0901	p 19	A87-34701 #
AIAA PAPER 87-0902	p 17	A87-33711 * #
AIAA PAPER 87-0903	p 17	A87-33712 * #
AIAA PAPER 87-0904	p 56	A87-33713 * #
AIAA PAPER 87-0906	p 57	A87-33714 * #
AIAA PAPER 87-0925	p 17	A87-33727 #
AIAA PAPER 87-0927	p 7	A87-33728 * #
AIAA PAPER 87-0930	p 57	A87-33730 #
AIAA PAPER 87-0931	p 57	A87-33731 * #
AIAA PAPER 87-0939	p 17	A87-33737 #
AIAA PAPER 87-0940	p 57	A87-33738 #
AIAA PAPER 87-0941	p 17	A87-33739 * #
AIAA PAPER 87-0943	p 18	A87-33741 #
AIAA PAPER 87-0944	p 18	A87-33742 #
AIAA PAPER 87-0948	p 18	A87-33745 #
AIAA PAPER 87-0959	p 18	A87-33751 #
AIAA PAPER 87-0961	p 18	A87-33752 * #
AIAA PAPER 87-0964	p 18	A87-33754 #
AIAA PAPER 87-0965	p 88	A87-38601 #
AIAA PAPER 87-0968	p 125	A87-38602 #
AIAA PAPER 87-0969	p 88	A87-38603 #
AIAA PAPER 87-0980	p 89	A87-38604 * #
AIAA PAPER 87-0984	p 58	A87-41103 * #
AIAA PAPER 87-1031	p 88	A87-38615 #
AIAA PAPER 87-1036	p 90	A87-41122 #
AIAA PAPER 87-1040	p 78	A87-38628 #
AIAA PAPER 87-1041	p 78	A87-38629 #
AIAA PAPER 87-1042	p 88	A87-38616 #
AIAA PAPER 87-1102	p 78	A87-41145 * #
AIAA PAPER 87-1468	p 43	A87-43003 #
AIAA PAPER 87-1469	p 77	A87-43004 #
AIAA PAPER 87-1482	p 43	A87-43014 #
AIAA PAPER 87-1488	p 90	A87-43027 * #
AIAA PAPER 87-1505	p 160	A87-43031 #
AIAA PAPER 87-1522	p 44	A87-44830 * #
AIAA PAPER 87-1525	p 43	A87-43048 * #
AIAA PAPER 87-1537	p 43	A87-43059 * #
AIAA PAPER 87-1540	p 44	A87-44843 * #
AIAA PAPER 87-1543	p 135	A87-43060 * #
AIAA PAPER 87-1558	p 90	A87-44832 #
AIAA PAPER 87-1586	p 43	A87-43100 * #
AIAA PAPER 87-1623	p 52	A87-43122 #
AIAA PAPER 87-1627	p 44	A87-43125 * #
AIAA PAPER 87-1629	p 44	A87-43126 * #
AIAA PAPER 87-1672	p 100	A87-41152 #
AIAA PAPER 87-1677	p 100	A87-41153 #
AIAA PAPER 87-1763	p 80	A87-45180 #
AIAA PAPER 87-1764	p 92	A87-48572 * #
AIAA PAPER 87-1767	p 91	A87-45181 *
AIAA PAPER 87-1768	p 135	A87-45182 #
AIAA PAPER 87-1775	p 91	A87-45188 #
AIAA PAPER 87-1858	p 91	A87-45255 * #
AIAA PAPER 87-1860	p 91	A87-45256 * #
AIAA PAPER 87-1862	p 152	A87-45257 #
AIAA PAPER 87-1863	p 44	A87-45258 #
AIAA PAPER 87-1864	p 91	A87-45259 * #
AIAA PAPER 87-1866	p 91	A87-45260 #
AIAA PAPER 87-1902	p 91	A87-45287 #
AIAA PAPER 87-1934	p 92	A87-45311 #
AIAA PAPER 87-2017	p 83	A87-52247 * #
AIAA PAPER 87-2018	p 92	A87-45357 #
AIAA PAPER 87-2021	p 92	A87-45360 #
AIAA PAPER 87-2027	p 77	A87-45363 #
AIAA PAPER 87-2120	p 83	A87-50197 * #
AIAA PAPER 87-2121	p 82	A87-52252 * #
AIAA PAPER 87-2155	p 92	A87-45439 #
AIAA PAPER 87-2157	p 160	A87-45441 #
AIAA PAPER 87-2180	p 153	A87-48578 #
AIAA PAPER 87-2181	p 153	A87-48579 #
AIAA PAPER 87-2183	p 153	A87-48580 #
AIAA PAPER 87-2186	p 153	A87-48581 #

AIAA PAPER 87-2196 p 119 A87-48582 * #
AIAA PAPER 87-2197 p 113 A87-48583 #
AIAA PAPER 87-2199 p 154 A87-48585 #
AIAA PAPER 87-2202 p 113 A87-48587 * #
AIAA PAPER 87-2203 p 113 A87-48588 * #
AIAA PAPER 87-2204 p 113 A87-48589 * #
AIAA PAPER 87-2205 p 113 A87-48590 #
AIAA PAPER 87-2207 p 154 A87-48592 #
AIAA PAPER 87-2208 p 114 A87-48593 * #
AIAA PAPER 87-2209 p 169 A87-48594 * #
AIAA PAPER 87-2210 p 154 A87-48595 #
AIAA PAPER 87-2211 p 154 A87-48596 #
AIAA PAPER 87-2213 p 119 A87-48597 * #
AIAA PAPER 87-2217 p 114 A87-48600 * #
AIAA PAPER 87-2219 p 2 A87-48601 #
AIAA PAPER 87-2221 p 7 A87-48602 #
AIAA PAPER 87-2227 p 154 A87-48605 #
AIAA PAPER 87-2228 p 114 A87-48606 * #
AIAA PAPER 87-2229 p 114 A87-48607 * #
AIAA PAPER 87-2238 p 60 A87-50404 #
AIAA PAPER 87-2248 p 7 A87-50412 * #
AIAA PAPER 87-2249 p 60 A87-50413 #
AIAA PAPER 87-2250 p 60 A87-50414 #
AIAA PAPER 87-2251 p 60 A87-50415 #
AIAA PAPER 87-2252 p 23 A87-50416 * #
AIAA PAPER 87-2253 p 68 A87-50417 #
AIAA PAPER 87-2321 p 23 A87-50442 #
AIAA PAPER 87-2322 p 23 A87-50443 #
AIAA PAPER 87-2323 p 23 A87-50444 #
AIAA PAPER 87-2324 p 24 A87-50445 #
AIAA PAPER 87-2325 p 24 A87-50446 #
AIAA PAPER 87-2326 p 128 A87-50447 #
AIAA PAPER 87-2387 p 24 A87-50471 * #
AIAA PAPER 87-2388 p 61 A87-50472 #
AIAA PAPER 87-2389 p 24 A87-50473 #
AIAA PAPER 87-2390 p 61 A87-50474 * #
AIAA PAPER 87-2391 p 61 A87-50475 #
AIAA PAPER 87-2456 p 24 A87-50502 #
AIAA PAPER 87-2457 p 61 A87-50503 #
AIAA PAPER 87-2458 p 24 A87-50504 #
AIAA PAPER 87-2459 p 61 A87-50505 * #
AIAA PAPER 87-2460 p 25 A87-50506 * #
AIAA PAPER 87-2461 p 25 A87-50507 #
AIAA PAPER 87-2464 p 60 A87-50509 * #
AIAA PAPER 87-2467 p 77 A87-50511 #
AIAA PAPER 87-2529 p 62 A87-50531 * #
AIAA PAPER 87-2530 p 161 A87-50533 #
AIAA PAPER 87-2565 p 62 A87-48915 * #
AIAA PAPER 87-2567 p 63 A87-48917 #
AIAA PAPER 87-2568 p 138 A87-48918 * #
AIAA PAPER 87-2588 p 62 A87-50558 * #
AIAA PAPER 87-2589 p 62 A87-50561 * #
AIAA PAPER 87-2600 p 62 A87-50562 * #
AIAA PAPER 87-2641 p 61 A87-50486 #

AIAA-87-0860 p 85 N87-22237 * #
AIAA-87-0894 p 63 N87-20477 * #
AIAA-87-1794 p 86 N87-22949 * #
AIAA-87-2120 p 86 N87-23821 * #
AIAA-87-9003 p 86 N87-22001 * #
AIAA-87-9035 p 78 N87-23028 * #
AIAA-87-9257 p 79 N87-24838 * #
AIAA-87-9353 p 88 N87-23880 * #
AIAA-87-9355 p 78 N87-22004 * #

ASME PAPER 86-GT-100 p 166 A87-25366 * #
ASME PAPER 87-APM-34 p 59 A87-42505 #

ATES-AN-86/488 p 79 N87-24530 #

B-226577 p 137 N87-22551 #

BAC-ER-18058-8 p 87 N87-24641 * #

BNL-38895 p 99 N87-28405 #

CONF-870102-23 p 99 N87-28405 #
CONF-870147-1 p 101 N87-22231 #
CONF-870148-1 p 101 N87-20774 #
CONF-870162-1 p 171 N87-22867 #
CONF-870354-2 p 102 N87-22230 #
CONF-870385-1 p 102 N87-22242 * #
CONF-8704101-1 p 88 N87-24028 #
CONF-870581-3 p 100 N87-27408 #

DE87-004816 p 101 N87-22231 #
DE87-004827 p 101 N87-20774 #
DE87-005326 p 102 N87-22230 #
DE87-006467 p 171 N87-22867 #
DE87-007012 p 102 N87-22242 * #
DE87-007867 p 88 N87-24028 #
DE87-009121 p 100 N87-27408 #
DE87-010080 p 99 N87-28405 #

DGLR PAPER 86-104 p 88 A87-36756
DGLR PAPER 86-122 p 101 A87-48156
DGLR PAPER 86-172 p 57 A87-36762
DGLR PAPER 86-175 p 153 A87-48157

DPD-685-VOL-1 p 131 N87-29585 * #

DR-4-VOL-1 p 131 N87-29585 * #

D180-30550-1 p 39 N87-29581 * #
D180-30550-2 p 39 N87-29582 * #
D180-30550-3 p 4 N87-29583 * #
D483-10080-1 p 54 N87-29584 * #

E-3366 p 84 N87-21141 * #
E-3410 p 86 N87-24536 * #
E-3460 p 87 N87-24641 * #
E-3483 p 93 N87-20378 * #
E-3506 p 5 N87-29914 * #
E-3510 p 44 N87-20353 * #
E-3511 p 165 N87-20342 * #
E-3521 p 85 N87-22237 * #
E-3527 p 63 N87-20477 * #
E-3530 p 121 N87-23874 * #
E-3531 p 86 N87-22003 * #
E-3569 p 78 N87-22174 * #
E-3577 p 86 N87-22001 * #
E-3580 p 79 N87-24838 * #
E-3581 p 78 N87-23028 * #
E-3617 p 86 N87-22949 * #
E-3626 p 78 N87-22004 * #
E-3629 p 88 N87-23880 * #
E-3646 p 87 N87-25422 * #
E-3649 p 86 N87-26135 * #
E-3657 p 86 N87-23821 * #
E-3669 p 107 N87-25480 * #
E-3692 p 80 N87-26144 * #

EI-279-R518 p 8 N87-21020 * #

EMSB-4/ /86 p 35 N87-24518 #

ESA-CR(P)-2313-VOL-1 p 70 N87-24514 #
ESA-CR(P)-2313-VOL-2 p 68 N87-24480 #
ESA-CR(P)-2313-VOL-3 p 69 N87-24481 #
ESA-CR(P)-2316 p 115 N87-26057 #
ESA-CR(P)-2319 p 79 N87-24533 #
ESA-CR(P)-2329 p 35 N87-24518 #
ESA-CR(P)-2338 p 158 N87-27888 #
ESA-CR(P)-2340 p 38 N87-26075 #
ESA-CR(P)-2346-VOL-1 p 102 N87-25336 #
ESA-CR(P)-2346-VOL-2 p 102 N87-24486 #
ESA-CR(P)-2346-VOL-3 p 102 N87-25337 #
ESA-CR(P)-2347 p 100 N87-26260 #
ESA-CR(P)-2348 p 97 N87-26058 #
ESA-CR(P)-2355 p 79 N87-24530 #
ESA-CR(P)-2361-VOL-1 p 73 N87-27706 #
ESA-CR(P)-2361-VOL-1 p 73 N87-27707 #
ESA-CR(P)-2361-VOL-2 p 73 N87-27708 #
ESA-CR(P)-2361-VOL-4 p 73 N87-27709 #
ESA-CR(P)-2362 p 115 N87-26585 #
ESA-CR(P)-2363 p 115 N87-26586 #
ESA-CR(P)-2367 p 138 N87-26588 #

ESA-SP-255 p 171 N87-25354 #
ESA-SP-266 p 129 N87-29621 #
ESA-SP-267 p 81 N87-28959 #

ETN-87-90157 p 81 N87-28959 #
ETN-87-90235 p 38 N87-27705 #
ETN-87-90462 p 73 N87-27706 #
ETN-87-90463 p 73 N87-27707 #
ETN-87-90464 p 73 N87-27708 #
ETN-87-90465 p 73 N87-27709 #
ETN-87-90466 p 115 N87-26585 #
ETN-87-90467 p 115 N87-26586 #
ETN-87-90471 p 138 N87-26588 #
ETN-87-99434 p 129 N87-29621 #
ETN-87-99872 p 79 N87-24532 #
ETN-87-99862 p 171 N87-25354 #
ETN-87-99868 p 70 N87-24514 #
ETN-87-99869 p 68 N87-24480 #
ETN-87-99870 p 69 N87-24481 #
ETN-87-99873 p 115 N87-26057 #
ETN-87-99875 p 79 N87-24533 #
ETN-87-99881 p 35 N87-24518 #
ETN-87-99886 p 102 N87-25336 #
ETN-87-99887 p 102 N87-24486 #
ETN-87-99888 p 102 N87-25337 #
ETN-87-99896 p 79 N87-24530 #
ETN-87-99930 p 30 N87-22289 #
ETN-87-99932 p 107 N87-25430 #
ETN-87-99936 p 130 N87-25506
ETN-87-99954 p 158 N87-25340 #
ETN-87-99955 p 158 N87-25418 #
ETN-87-99957 p 158 N87-27888 #
ETN-87-99961 p 38 N87-26075 #
ETN-87-99964 p 100 N87-26260 #
ETN-87-99965 p 97 N87-26058 #

FOK-TR-R-86-091-VOL-1 p 102 N87-25336 #
FOK-TR-R-86-091-VOL-2 p 102 N87-24486 #
FOK-TR-R-86-091-VOL-3 p 102 N87-25337 #

FSR-DR-15-VOL-1 p 78 N87-23695 * #
FSR-DR-15-VOL-2 p 79 N87-23696 * #

FTMS-RPT-006 p 97 N87-26058 #

GAO/IMTEC-87-20 p 137 N87-22551 #

GDSS-CRAD-87-004 p 67 N87-26081 * #

GDSS-SP-86-011-VOL-1A p 161 N87-21018 * #

GE-DOC-87SDS-024 p 9 N87-21995 * #

GPO-69-356 p 171 N87-25024 #
GPO-73-245 p 172 N87-30221 #
GPO-73-418 p 171 N87-22560 #

H-REPT-100-204 p 171 N87-25024 #

IAF PAPER 86-182 p 90 A87-42880

IAF-86-212 p 30 N87-22289 #
IAF-86-38 p 121 N87-26841
IAF-86-61 p 130 N87-25506
IAF-87-234 p 80 N87-26144 * #
IAF-87-259 p 86 N87-26135 * #

ICASE-83-25 p 11 N87-30107 * #

IITRI-M06124-F p 110 N87-28584 #

ILR-MITT-180 p 79 N87-24532 #

ISBN-92-835-0389-1 p 26 N87-20355 #
ISBN-92-835-0418-6 p 142 N87-26937 #

ISSN-0379-6566 p 129 N87-29621 #
ISSN-0379-6566 p 81 N87-28959 #
ISSN-079-6566 p 171 N87-25354 #

JPL-PUB-86-47 p 79 N87-25838 * #
JPL-PUB-87-14 p 141 N87-26173 * #

JPRS-USP-86-004 p 158 N87-27887 #

L-16183 p 28 N87-20567 * #
L-16242-PT-2 p 34 N87-24495 * #

LC-86-600589 p 171 N87-21754 #

LMSC-F177633 p 36 N87-25808 * #

LP-RP-AI-204-VOL-1 p 70 N87-24514 #
LP-RP-AI-204-VOL-2 p 68 N87-24480 #
LP-RP-AI-204-VOL-3 p 69 N87-24481 #

M-548 p 64 N87-20885 * #
M-554-PT-1 p 65 N87-22702 * #
M-554-PT-2 p 66 N87-22729 * #

MATRA-RF/176/0832-ISS-1 p 115 N87-26586 #

MBB-UD-489/86 p 30 N87-22289 #
MBB-UD-492/86 p 107 N87-25430 #

MBB-UR-E-907-86-PUB p 154 A87-48867 #
MBB-UR-E-912/86 p 156 N87-26842
MBB-UR-E-921/86 p 158 N87-25340 #
MBB-UR-E-922/86 p 158 N87-25418 #
MBB-UR-E-923/86 p 121 N87-26841

MBB-UR-873/86 p 130 N87-25506
MBB-UR-877-86-PUB p 90 A87-42880

MCR-85-640 p 30 N87-21887 * #

MDC-W0070 p 120 N87-20361 * #

MIT-SSL-1-87 p 72 N87-25806 #

NAS 1.15:100102 p 79 N87-24838 * #
NAS 1.15:100108 p 87 N87-25422 * #
NAS 1.15:100110 p 86 N87-26135 * #
NAS 1.15:100113 p 86 N87-23821 * #
NAS 1.15:100122 p 107 N87-25480 * #
NAS 1.15:100140 p 80 N87-26144 * #
NAS 1.15:100008 p 35 N87-24520 * #
NAS 1.15:100009 p 70 N87-24521 * #
NAS 1.15:100488 p 100 N87-29560 * #
NAS 1.15:88279 p 53 N87-27392 * #

NAS 1.15:86558 p 64 N87-21950 * #
NAS 1.15:86594 p 70 N87-24723 * #
NAS 1.15:86656 p 52 N87-24064 * #
NAS 1.15:87620 p 129 N87-22457 * #
NAS 1.15:87626 p 115 N87-27443 * #
NAS 1.15:88857 p 96 N87-24536 * #
NAS 1.15:89051 p 68 N87-23687 * #
NAS 1.15:89068 p 37 N87-26085 * #
NAS 1.15:89072 p 25 N87-20352 * #
NAS 1.15:89111 p 140 N87-20795 * #
NAS 1.15:89118 p 86 N87-20339 * #
NAS 1.15:89137 p 45 N87-21021 * #
NAS 1.15:89221 p 137 N87-25339 * #
NAS 1.15:89285 p 116 N87-29124 * #
NAS 1.15:89286 p 116 N87-29144 * #
NAS 1.15:89295 p 79 N87-25838 * #
NAS 1.15:89355 p 53 N87-27407 * #
NAS 1.15:89429-VOL-1 p 129 N87-22571 * #
NAS 1.15:89429-VOL-2 p 129 N87-22570 * #
NAS 1.15:89436 p 128 N87-20641 * #
NAS 1.15:89459 p 171 N87-25760 * #
NAS 1.15:89647 p 93 N87-20378 * #
NAS 1.15:89648 p 165 N87-20342 * #
NAS 1.15:89652 p 44 N87-20353 * #
NAS 1.15:89654 p 86 N87-22237 * #
NAS 1.15:89660 p 63 N87-20477 * #
NAS 1.15:89663 p 121 N87-23874 * #
NAS 1.15:89664 p 86 N87-22003 * #
NAS 1.15:89666 p 78 N87-22174 * #
NAS 1.15:89669 p 86 N87-22001 * #
NAS 1.15:89906 p 78 N87-23026 * #
NAS 1.15:89921 p 86 N87-22949 * #
NAS 1.15:89925 p 78 N87-22004 * #
NAS 1.15:89926 p 68 N87-23680 * #
NAS 1.21:7046(17) p 39 N87-29576 *
NAS 1.21:7056(04) p 4 N87-28073 *
NAS 1.26:171978 p 136 N87-20335 * #
NAS 1.26:171981 p 120 N87-20351 * #
NAS 1.26:172002 p 81 N87-26188 * #
NAS 1.26:172003 p 53 N87-29117 * #
NAS 1.26:175093 p 54 N87-29584 * #
NAS 1.26:177447 p 130 N87-25767 * #
NAS 1.26:178147 p 30 N87-21887 * #
NAS 1.26:178192 p 9 N87-21895 * #
NAS 1.26:178208 p 120 N87-20340 * #
NAS 1.26:178276 p 8 N87-21020 * #
NAS 1.26:178287 p 35 N87-25349 * #
NAS 1.26:178299 p 10 N87-24709 * #
NAS 1.26:178310 p 120 N87-24162 * #
NAS 1.26:179055 p 161 N87-21018 * #
NAS 1.26:179085 p 67 N87-22758 * #
NAS 1.26:179138 p 97 N87-28081 * #
NAS 1.26:179139 p 97 N87-28082 * #
NAS 1.26:179140 p 3 N87-28083 * #
NAS 1.26:179141 p 4 N87-28086 * #
NAS 1.26:179142 p 4 N87-28087 * #
NAS 1.26:179143 p 3 N87-28085 * #
NAS 1.26:179144 p 3 N87-28084 * #
NAS 1.26:179147 p 71 N87-25801 * #
NAS 1.26:179149 p 130 N87-26083 * #
NAS 1.26:179165 p 39 N87-28581 * #
NAS 1.26:179166 p 39 N87-28582 * #
NAS 1.26:179167 p 4 N87-28583 * #
NAS 1.26:179185 p 131 N87-29585 * #
NAS 1.26:179587-VOL-1 p 78 N87-23695 * #
NAS 1.26:179587-VOL-2 p 79 N87-23696 * #
NAS 1.26:180276 p 10 N87-27412 * #
NAS 1.26:180301 p 137 N87-26927 * #
NAS 1.26:180303 p 38 N87-26583 * #
NAS 1.26:180312 p 45 N87-26838 * #
NAS 1.26:180317 p 38 N87-27260 * #
NAS 1.26:180342 p 53 N87-27405 * #
NAS 1.26:180391 p 70 N87-24513 * #
NAS 1.26:180449 p 11 N87-30107 * #
NAS 1.26:180564 p 36 N87-26071 * #
NAS 1.26:180579 p 129 N87-22508 * #
NAS 1.26:180633 p 37 N87-26365 * #
NAS 1.26:180688 p 28 N87-20569 * #
NAS 1.26:180829 p 81 N87-26625 * #
NAS 1.26:180920 p 157 N87-21996 * #
NAS 1.26:180922 p 129 N87-22509 * #
NAS 1.26:180923 p 102 N87-22242 * #
NAS 1.26:181004 p 140 N87-23096 * #
NAS 1.26:181009 p 45 N87-26072 * #
NAS 1.26:181065 p 34 N87-23880 * #
NAS 1.26:181073 p 115 N87-24817 * #
NAS 1.26:181095 p 37 N87-26370 * #
NAS 1.26:181128 p 137 N87-25443 * #
NAS 1.26:181130 p 72 N87-26038 * #
NAS 1.26:181156 p 36 N87-25805 * #
NAS 1.26:181163 p 141 N87-26173 * #
NAS 1.26:181165 p 141 N87-26062 * #
NAS 1.26:181202 p 37 N87-26367 * #
NAS 1.26:181221 p 45 N87-27702 * #
NAS 1.26:181253 p 72 N87-27704 * #
NAS 1.26:181257 p 73 N87-27712 * #
NAS 1.26:181361 p 39 N87-29580 * #
NAS 1.26:181396 p 132 N87-29633 * #
NAS 1.26:181413 p 40 N87-29886 * #
NAS 1.26:181414 p 74 N87-29713 * #
NAS 1.26:181422 p 131 N87-29591 * #
NAS 1.26:4010 p 165 N87-21585 * #
NAS 1.26:4068 p 36 N87-25606 * #
NAS 1.26:4072 p 67 N87-24641 * #
NAS 1.26:4075 p 65 N87-21984 * #
NAS 1.26:4091 p 53 N87-28386 * #
NAS 1.26:4099 p 40 N87-29889 * #
NAS 1.55:2447-PT-2 p 34 N87-24495 * #
NAS 1.55:2460 p 64 N87-20865 * #
NAS 1.55:2465 p 94 N87-21141 * #
NAS 1.55:2467-PT-1 p 65 N87-22702 * #
NAS 1.55:2467-PT-2 p 66 N87-22725 * #
NAS 1.55:2470 p 103 N87-29858 * #
NAS 1.55:2484 p 5 N87-29914 * #
NAS 1.60:2661 p 28 N87-20567 * #
NAS 1.60:2690 p 63 N87-20380 * #
NAS 1.60:2710 p 28 N87-20568 * #

NASA-CASE-KSC-11368-1 p 102 N87-25583 * #

NASA-CASE-LAR-13113-1 p 36 N87-25492 *
NASA-CASE-LAR-13383-1 p 103 N87-29118 *
NASA-CASE-LAR-13455-1 p 29 N87-21208 *
NASA-CASE-LAR-13489-1 p 36 N87-27713 *
NASA-CASE-LAR-13660-1 p 165 N87-25581 * #

NASA-CASE-LEW-14072-3 p 107 N87-23738 *

NASA-CASE-MFS-28185-1 p 107 N87-25586 * #

NASA-CASE-MSC-20910-1 p 161 N87-25582 *
NASA-CASE-MSC-21207-1 p 36 N87-25576 * #

NASA-CASE-NPO-16840-1-CU p 8 N87-21881 *

NASA-CP-2447-PT-2 p 34 N87-24495 * #
NASA-CP-2460 p 64 N87-20865 * #
NASA-CP-2465 p 94 N87-21141 * #
NASA-CP-2467-PT-1 p 65 N87-22702 * #
NASA-CP-2467-PT-2 p 66 N87-22725 * #
NASA-CP-2470 p 103 N87-29858 * #
NASA-CP-2484 p 5 N87-29914 * #

NASA-CR-171978 p 136 N87-20335 * #
NASA-CR-171981 p 120 N87-20351 * #
NASA-CR-172002 p 81 N87-26188 * #
NASA-CR-172003 p 53 N87-29117 * #
NASA-CR-175093 p 54 N87-29584 * #
NASA-CR-177447 p 130 N87-25767 * #
NASA-CR-178147 p 30 N87-21887 * #
NASA-CR-178192 p 9 N87-21895 * #
NASA-CR-178208 p 120 N87-20340 * #
NASA-CR-178276 p 8 N87-21020 * #
NASA-CR-178287 p 35 N87-25349 * #
NASA-CR-178299 p 10 N87-24709 * #
NASA-CR-178310 p 120 N87-24162 * #
NASA-CR-179055 p 161 N87-21018 * #
NASA-CR-179085 p 67 N87-22758 * #
NASA-CR-179138 p 97 N87-28081 * #
NASA-CR-179139 p 97 N87-28082 * #
NASA-CR-179140 p 3 N87-28083 * #
NASA-CR-179141 p 4 N87-28086 * #
NASA-CR-179142 p 4 N87-28087 * #
NASA-CR-179143 p 3 N87-28085 * #
NASA-CR-179144 p 3 N87-28084 * #
NASA-CR-179147 p 71 N87-25801 * #
NASA-CR-179149 p 130 N87-26083 * #
NASA-CR-179165 p 39 N87-28581 * #
NASA-CR-179166 p 39 N87-28582 * #
NASA-CR-179167 p 4 N87-28583 * #
NASA-CR-179185 p 131 N87-29585 * #
NASA-CR-179587-VOL-1 p 78 N87-23695 * #
NASA-CR-179587-VOL-2 p 79 N87-23696 * #
NASA-CR-180276 p 10 N87-27412 * #
NASA-CR-180301 p 137 N87-26927 * #
NASA-CR-180303 p 38 N87-26583 * #
NASA-CR-180312 p 45 N87-26838 * #
NASA-CR-180317 p 38 N87-27260 * #
NASA-CR-180342 p 53 N87-27405 * #
NASA-CR-180391 p 70 N87-24513 * #
NASA-CR-180449 p 11 N87-30107 * #
NASA-CR-180564 p 36 N87-26071 * #
NASA-CR-180579 p 129 N87-22508 * #
NASA-CR-180633 p 37 N87-26365 * #
NASA-CR-180688 p 28 N87-20569 * #
NASA-CR-180829 p 81 N87-26625 * #
NASA-CR-180920 p 157 N87-21996 * #
NASA-CR-180922 p 129 N87-22509 * #
NASA-CR-180923 p 102 N87-22242 * #
NASA-CR-181004 p 140 N87-23096 * #
NASA-CR-181009 p 45 N87-26072 * #
NASA-CR-181065 p 34 N87-23880 * #
NASA-CR-181073 p 115 N87-24817 * #
NASA-CR-181095 p 37 N87-26370 * #
NASA-CR-181128 p 137 N87-25443 * #
NASA-CR-181130 p 72 N87-26038 * #
NASA-CR-181156 p 36 N87-25805 * #
NASA-CR-181163 p 141 N87-26173 * #
NASA-CR-181165 p 141 N87-26062 * #
NASA-CR-181202 p 37 N87-26367 * #
NASA-CR-181221 p 45 N87-27702 * #
NASA-CR-181253 p 72 N87-27704 * #
NASA-CR-181257 p 73 N87-27712 * #
NASA-CR-181361 p 39 N87-29580 * #
NASA-CR-181396 p 132 N87-29633 * #
NASA-CR-181413 p 40 N87-29886 * #
NASA-CR-181414 p 74 N87-29713 * #
NASA-CR-181422 p 131 N87-29591 * #
NASA-CR-4010 p 165 N87-21585 * #
NASA-CR-4068 p 36 N87-25606 * #
NASA-CR-4072 p 67 N87-24641 * #
NASA-CR-4075 p 65 N87-21984 * #
NASA-CR-4091 p 53 N87-28386 * #
NASA-CR-4099 p 40 N87-29889 * #

NASA-SP-7046(17) p 39 N87-29576 *
NASA-SP-7056(04) p 4 N87-28073 *

NASA-TM-100102 p 79 N87-24836 * #
NASA-TM-100108 p 87 N87-25422 * #
NASA-TM-100110 p 88 N87-26135 * #
NASA-TM-100113 p 86 N87-23821 * #
NASA-TM-100122 p 107 N87-25480 * #
NASA-TM-100140 p 80 N87-26144 * #
NASA-TM-100308 p 35 N87-24520 * #
NASA-TM-100309 p 70 N87-24521 * #
NASA-TM-100480 p 109 N87-29563 * #
NASA-TM-58279 p 53 N87-27392 * #
NASA-TM-86558 p 64 N87-21950 * #
NASA-TM-86594 p 70 N87-24723 * #
NASA-TM-86656 p 52 N87-24064 * #
NASA-TM-87620 p 129 N87-22457 * #
NASA-TM-87626 p 115 N87-27443 * #
NASA-TM-88857 p 96 N87-24536 * #
NASA-TM-89051 p 68 N87-23687 * #
NASA-TM-89068 p 37 N87-26085 * #
NASA-TM-89072 p 25 N87-20352 * #
NASA-TM-89111 p 140 N87-20795 * #
NASA-TM-89118 p 86 N87-20339 * #
NASA-TM-89137 p 45 N87-21021 * #
NASA-TM-89221 p 137 N87-25339 * #
NASA-TM-89285 p 116 N87-29124 * #
NASA-TM-89286 p 116 N87-29144 * #
NASA-TM-89295 p 79 N87-25838 * #
NASA-TM-89355 p 53 N87-27407 * #
NASA-TM-89429-VOL-1 p 129 N87-22571 * #
NASA-TM-89429-VOL-2 p 129 N87-22570 * #
NASA-TM-89436 p 128 N87-20641 * #
NASA-TM-89459 p 171 N87-25760 * #
NASA-TM-89647 p 93 N87-20378 * #
NASA-TM-89648 p 165 N87-20342 * #
NASA-TM-89652 p 44 N87-20353 * #
NASA-TM-89654 p 86 N87-22237 * #
NASA-TM-89660 p 63 N87-20477 * #
NASA-TM-89663 p 121 N87-23874 * #
NASA-TM-89664 p 86 N87-22003 * #
NASA-TM-89666 p 78 N87-22174 * #
NASA-TM-89669 p 86 N87-22001 * #
NASA-TM-89906 p 78 N87-23026 * #
NASA-TM-89921 p 86 N87-22949 * #
NASA-TM-89925 p 78 N87-22004 * #
NASA-TM-89926 p 68 N87-23680 * #

NASA-TP-2661 p 28 N87-20567 * #
NASA-TP-2690 p 63 N87-20380 * #
NASA-TP-2710 p 28 N87-20568 * #

NE-51-867 p 115 N87-28057 #

NOAA-NESDIS-30 p 130 N87-25680 #

OTA-BP-ISC-41 p 171 N87-21754 #

PB87-118220 p 171 N87-21754 #

REPORT-85SDS2184-VOL-1B-PT-1 p 4 N87-28086 * #

REPT-85SDS2184-VOL-1A-PT-1 p 97 N87-28082 * #
REPT-85SDS2184-VOL-1A-PT-2 p 3 N87-28083 * #
REPT-85SDS2184-VOL-1B-PT-2 p 4 N87-28087 * #
REPT-85SDS2184-VOL-2 p 3 N87-28085 * #
REPT-85SDS2184-VOL-3 p 3 N87-28084 * #
REPT-87B0275 p 129 N87-22457 * #
REPT-87B0343 p 115 N87-27443 * #

S-REPT-100-67 p 171 N87-24240 #

S-558 p 53 N87-27392 * #

S-560 p 103 N87-29858 * #

SAE P-177 p 182 A87-38701

SAE PAPER 860916 p 47 A87-38708 *
SAE PAPER 860918 p 118 A87-38710 *
SAE PAPER 860920 p 47 A87-38712
SAE PAPER 860921 p 183 A87-38713
SAE PAPER 860923 p 183 A87-38714 *
SAE PAPER 860924 p 139 A87-38715 *
SAE PAPER 860926 p 47 A87-38716
SAE PAPER 860927 p 183 A87-38717
SAE PAPER 860929 p 183 A87-38718
SAE PAPER 860930 p 48 A87-38720 *
SAE PAPER 860931 p 183 A87-38721 *
SAE PAPER 860932 p 118 A87-38722 *
SAE PAPER 860933 p 167 A87-38723
SAE PAPER 860934 p 183 A87-38724 *
SAE PAPER 860936 p 42 A87-38725
SAE PAPER 860938 p 150 A87-38727
SAE PAPER 860939 p 150 A87-38728
SAE PAPER 860942 p 48 A87-38729 *
SAE PAPER 860943 p 48 A87-38730 *
SAE PAPER 860944 p 48 A87-38731 *
SAE PAPER 860945 p 48 A87-38732
SAE PAPER 860946 p 48 A87-38733 *
SAE PAPER 860947 p 42 A87-38734 *
SAE PAPER 860948 p 49 A87-38735
SAE PAPER 860949 p 49 A87-38736
SAE PAPER 860950 p 49 A87-38737
SAE PAPER 860951 p 49 A87-38738
SAE PAPER 860952 p 184 A87-38739
SAE PAPER 860953 p 184 A87-38740 *
SAE PAPER 860956 p 184 A87-38741
SAE PAPER 860958 p 118 A87-38742 *
SAE PAPER 860959 p 42 A87-38743
SAE PAPER 860965 p 150 A87-38747
SAE PAPER 860966 p 150 A87-38748
SAE PAPER 860967 p 49 A87-38749
SAE PAPER 860968 p 49 A87-38750
SAE PAPER 860969 p 184 A87-38751 *
SAE PAPER 860970 p 50 A87-38752 *
SAE PAPER 860971 p 50 A87-38753
SAE PAPER 860972 p 120 A87-38754 *
SAE PAPER 860973 p 134 A87-38755 *
SAE PAPER 860974 p 124 A87-38756 *
SAE PAPER 860975 p 124 A87-38757 *
SAE PAPER 860979 p 42 A87-38760
SAE PAPER 860982 p 50 A87-38761 *
SAE PAPER 860983 p 50 A87-38762 *
SAE PAPER 860984 p 50 A87-38763 *
SAE PAPER 860985 p 50 A87-38764 *
SAE PAPER 860986 p 51 A87-38765
SAE PAPER 860987 p 51 A87-38766 *
SAE PAPER 860990 p 134 A87-38767
SAE PAPER 860991 p 184 A87-38768
SAE PAPER 860992 p 134 A87-38769 *
SAE PAPER 860993 p 51 A87-38770 *
SAE PAPER 860994 p 51 A87-38771 *
SAE PAPER 860995 p 51 A87-38772 *
SAE PAPER 860996 p 51 A87-38773 *
SAE PAPER 860997 p 51 A87-38774
SAE PAPER 860998 p 42 A87-38775 *
SAE PAPER 860999 p 42 A87-38776
SAE PAPER 861005 p 86 A87-38778 *
SAE PAPER 861007 p 52 A87-38779
SAE PAPER 861008 p 134 A87-38780
SAE PAPER 861009 p 134 A87-38781
SAE PAPER 861010 p 135 A87-38782
SAE PAPER 861013 p 180 A87-38783
SAE PAPER 861014 p 119 A87-38784 *
SAE PAPER 861621 p 74 A87-32578
SAE PAPER 861622 p 74 A87-32579
SAE PAPER 861681 p 180 A87-32598 *
SAE PAPER 861723 p 132 A87-32612
SAE PAPER 861724 p 118 A87-32613
SAE PAPER 861764 p 1 A87-32625
SAE PAPER 861783 p 47 A87-32632
SAE PAPER 861784 p 89 A87-32633
SAE PAPER 861785 p 133 A87-32634 *
SAE PAPER 861790 p 5 A87-32639
SAE PAPER 861796 p 133 A87-32644
SAE PAPER 861797 p 88 A87-32645
SAE PAPER 861818 p 147 A87-32655
SAE PAPER 861821 p 6 A87-32657 *
SAE PAPER 861822 p 13 A87-32658 *
SAE PAPER 861825 p 41 A87-32660 *
SAE PAPER 861826 p 41 A87-32662
SAE PAPER 861829 p 41 A87-32663 *
SAE PAPER 861831 p 41 A87-32665
SAE PAPER 861833 p 41 A87-32666 *
SAE PAPER 861834 p 133 A87-32667 *

SAIC-1-120-779-C14 p 138 N87-20335 * #
SAIC-87/1514 p 138 N87-20335 * #

SAR-2 p 126 N87-22506 * #

SAWE PAPER 1692 p 20 A87-36279

SCC-86-02 p 140 N87-21881 #

SD-TR-86-62 p 140 N87-21024 #
SD-TR-87-24 p 110 N87-25709 #

SEI-TR-86-13 p 29 N87-21366 #
SEI-TR-86-14 p 35 N87-24117 #

SES/DHP/TR/002/85 p 115 N87-26585 #

SES/ENG/ES-019/86 p 138 N87-26586 #

SPIE-644 p 125 A87-44176 *

SR-5 p 131 N87-26667 #

SSL-22-86 p 37 N87-26365 * #

SSS-R-87-8495 p 131 N87-26667 #

SVIC-BULL-56-PT-1 p 29 N87-20574 #

TR-0086(6935-05)-2 p 110 N87-25709 #
TR-0086(6940-05)-13 p 140 N87-21024 #

TRW-42543-6011-UE-00 p 140 N87-23579 #

UCRL-95258 p 171 N87-22697 #

US-PATENT-APPL-SN-032818 p 38 N87-25576 * #
US-PATENT-APPL-SN-052940 p 102 N87-25583 * #
US-PATENT-APPL-SN-052941 p 165 N87-25581 * #
US-PATENT-APPL-SN-056830 p 107 N87-25586 * #
US-PATENT-APPL-SN-840838 p 93 N87-20375
US-PATENT-APPL-SN-780799 p 103 N87-29118 *
US-PATENT-APPL-SN-783888 p 161 N87-25582 *
US-PATENT-APPL-SN-804040 p 29 N87-21208 *
US-PATENT-APPL-SN-821371 p 38 N87-25492 *
US-PATENT-APPL-SN-834677 p 107 N87-23738 *
US-PATENT-APPL-SN-852469 p 8 N87-21681 *
US-PATENT-APPL-SN-890445 p 38 N87-27713 *

US-PATENT-CLASS-182-152 p 38 N87-25492 *
US-PATENT-CLASS-182-223 p 103 N87-29118 *
US-PATENT-CLASS-182-63 p 103 N87-29118 *
US-PATENT-CLASS-182-82 p 103 N87-29118 *
US-PATENT-CLASS-244-161 p 161 N87-25582 *
US-PATENT-CLASS-250-251 p 8 N87-21681 *
US-PATENT-CLASS-250-341 p 29 N87-21208 *
US-PATENT-CLASS-250-398-R p 8 N87-21681 *
US-PATENT-CLASS-250-423-P p 8 N87-21681 *
US-PATENT-CLASS-285-27 p 38 N87-27713 *
US-PATENT-CLASS-285-31 p 38 N87-27713 *
US-PATENT-CLASS-285-373 p 38 N87-27713 *
US-PATENT-CLASS-285-421 p 38 N87-27713 *
US-PATENT-CLASS-285-93 p 38 N87-27713 *
US-PATENT-CLASS-292-DIG.49 p 161 N87-25582 *
US-PATENT-CLASS-292-201 p 161 N87-25582 *
US-PATENT-CLASS-292-84 p 161 N87-25582 *
US-PATENT-CLASS-374-122 p 29 N87-21208 *
US-PATENT-CLASS-374-8 p 29 N87-21208 *
US-PATENT-CLASS-376-127 p 8 N87-21681 *
US-PATENT-CLASS-403-341 p 38 N87-27713 *
US-PATENT-CLASS-428-421 p 107 N87-23738 *
US-PATENT-CLASS-428-422 p 107 N87-23738 *
US-PATENT-CLASS-428-447 p 107 N87-23738 *
US-PATENT-CLASS-428-473.5 p 107 N87-23738 *
US-PATENT-CLASS-428-702 p 107 N87-23738 *
US-PATENT-CLASS-52-108 p 38 N87-25492 *
US-PATENT-CLASS-52-632 p 38 N87-25492 *
US-PATENT-CLASS-52-646 p 38 N87-25492 *

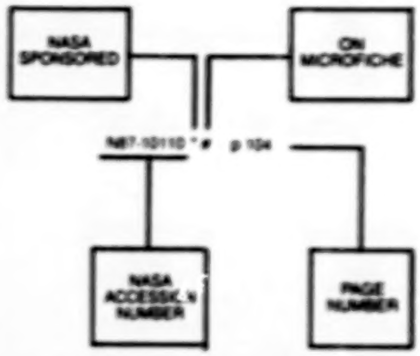
US-PATENT-4,638,169 p 93 N87-20375
US-PATENT-4,645,358 p 29 N87-21208 *
US-PATENT-4,649,273 p 8 N87-21681 *
US-PATENT-4,664,980 p 107 N87-23738 *
US-PATENT-4,677,803 p 38 N87-25492 *
US-PATENT-4,682,745 p 161 N87-25582 *
US-PATENT-4,684,158 p 38 N87-27713 *
US-PATENT-4,685,535 p 103 N87-29118 *

USC-53-4507-0031 p 70 N87-24513 * #

UVA/528224-MAE86-105 p 72 N87-27704 * #

ACCESSION NUMBER INDEX

Typical Accession Number Index Listing



Listings in this index are arranged alpha-numerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A87-25388 *# p 168
A87-29133 p 5
A87-31461 *# p 84
A87-31462 * p 84
A87-31463 p 111
A87-31480 p 89
A87-31505 p 11
A87-31516 p 111
A87-31681 * p 54
A87-32006 p 132
A87-32017 * p 168
A87-32058 * p 11
A87-32059 p 105
A87-32060 p 105
A87-32061 * p 105
A87-32075 p 111
A87-32116 p 1
A87-32117 p 54
A87-32120 p 11
A87-32121 * p 5
A87-32175 *# p 40
A87-32182 *# p 121
A87-32229 # p 11
A87-32235 *# p 84
A87-32236 *# p 121
A87-32276 p 168
A87-32277 * p 1
A87-32278 p 143
A87-32280 p 143
A87-32281 p 143
A87-32282 p 143
A87-32285 p 143
A87-32286 p 168
A87-32288 p 121
A87-32306 p 74
A87-32334 p 144
A87-32335 p 144
A87-32336 * p 11
A87-32337 * p 12
A87-32338 p 54
A87-32339 p 144
A87-32340 p 12
A87-32341 p 144
A87-32342 p 105
A87-32348 p 144
A87-32368 p 144
A87-32369 p 40
A87-32370 p 144
A87-32377 p 41
A87-32380 p 143
A87-32405 p 12
A87-32440 p 54
A87-32441 p 54
A87-32442 p 12
A87-32443 p 12
A87-32444 p 55
A87-32446 p 55
A87-32447 p 55
A87-32448 p 55
A87-32449 p 89
A87-32455 p 46
A87-32456 p 145
A87-32457 p 46
A87-32458 p 46
A87-32459 p 46
A87-32460 p 168
A87-32474 p 132
A87-32475 p 145
A87-32507 p 145
A87-32521 p 121
A87-32528 p 145
A87-32529 p 118
A87-32530 p 145
A87-32531 p 145
A87-32532 p 145
A87-32533 p 122
A87-32534 p 146
A87-32535 p 146
A87-32536 p 122
A87-32537 p 146
A87-32538 p 122
A87-32539 p 146
A87-32540 p 146
A87-32541 p 146
A87-32542 p 147
A87-32543 p 132
A87-32544 p 46
A87-32545 p 12
A87-32546 p 147
A87-32547 p 147
A87-32548 p 12
A87-32549 p 180
A87-32578 p 74
A87-32579 p 74
A87-32588 * p 180
A87-32612 p 132
A87-32613 p 118
A87-32625 p 1
A87-32632 p 47
A87-32633 p 88
A87-32634 * p 133
A87-32639 p 5
A87-32644 p 133
A87-32645 p 88
A87-32655 p 147
A87-32657 * p 6
A87-32658 * p 13
A87-32662 p 41
A87-32663 * p 41
A87-32665 p 41
A87-32666 * p 41
A87-32667 * p 133
A87-32668 * p 41
A87-32726 p 55
A87-32727 * p 55
A87-32729 p 13
A87-32730 p 55
A87-32732 * p 56
A87-32733 * p 133
A87-32738 * p 56
A87-32741 p 56
A87-32743 * p 133
A87-32744 * p 133
A87-32745 * p 89
A87-32746 * p 89
A87-32747 * p 75
A87-32801 p 147
A87-32802 p 1
A87-32814 p 147
A87-32815 p 148
A87-32816 p 148
A87-33001 p 162
A87-33002 p 162
A87-33003 * p 118
A87-33013 p 47
A87-33016 * p 167
A87-33021 p 162
A87-33022 p 162
A87-33040 p 111
A87-33048 p 118
A87-33070 p 6
A87-33135 *# p 105
A87-33475 p 162
A87-33551 p 13
A87-33557 # p 6
A87-33560 *# p 6
A87-33561 *# p 6
A87-33564 # p 13
A87-33565 *# p 13
A87-33573 *# p 56
A87-33589 # p 13
A87-33591 # p 14
A87-33610 *# p 14
A87-33611 *# p 14
A87-33613 *# p 14
A87-33632 # p 14
A87-33633 *# p 15
A87-33634 *# p 15
A87-33635 # p 15
A87-33638 *# p 15
A87-33639 # p 105
A87-33664 p 15
A87-33665 *# p 15
A87-33666 *# p 6
A87-33667 # p 148
A87-33669 # p 16
A87-33670 *# p 16
A87-33679 # p 16
A87-33687 # p 122
A87-33688 *# p 16
A87-33705 *# p 16
A87-33708 *# p 16
A87-33709 *# p 17
A87-33710 # p 56
A87-33711 *# p 17
A87-33712 *# p 17
A87-33713 *# p 56
A87-33714 *# p 57
A87-33727 # p 17
A87-33729 *# p 7
A87-33730 # p 57
A87-33731 *# p 57
A87-33737 # p 17
A87-33738 # p 57
A87-33739 *# p 17
A87-33741 # p 18
A87-33742 # p 18
A87-33745 # p 18
A87-33751 # p 18
A87-33752 *# p 18
A87-33754 # p 19
A87-33756 *# p 19
A87-33757 # p 19
A87-33767 * p 75
A87-33887 *# p 100
A87-34047 p 148
A87-34207 p 148
A87-34208 p 148
A87-34345 p 148
A87-34485 *# p 139
A87-34487 # p 19
A87-34489 *# p 42
A87-34510 # p 19
A87-34584 p 149
A87-34585 p 149
A87-34587 p 167
A87-34701 # p 19
A87-34712 * p 89
A87-34797 p 84
A87-34870 p 167
A87-34871 p 122
A87-34874 p 149
A87-35076 # p 149
A87-35077 # p 149
A87-35222 * p 122
A87-35262 p 111
A87-35327 p 19
A87-35585 p 162
A87-35690 p 47
A87-35718 * p 7
A87-35768 p 75
A87-35877 p 149
A87-36276 p 20
A87-36282 p 134
A87-36531 * p 123
A87-36758 p 88
A87-36762 p 57
A87-36813 *# p 75
A87-36844 p 75
A87-37135 p 7
A87-37291 *# p 75
A87-37293 *# p 111
A87-37294 *# p 112
A87-37295 * p 58
A87-37297 *# p 134
A87-37298 * p 7
A87-37300 *# p 100
A87-37431 p 112
A87-37785 p 123
A87-37853 p 149
A87-37862 p 150
A87-37863 p 1
A87-37864 p 150
A87-37868 * p 112
A87-37871 p 150
A87-38001 # p 88
A87-38002 # p 123
A87-38003 # p 88
A87-38004 *# p 88
A87-38015 # p 88
A87-38016 # p 88
A87-38443 p 150
A87-38567 * p 123
A87-38568 * p 123
A87-38569 * p 88
A87-38570 p 123
A87-38571 * p 123
A87-38572 * p 88
A87-38573 p 124
A87-38574 * p 124
A87-38576 p 167
A87-38579 p 167
A87-38800 p 20
A87-38801 * p 20
A87-38809 * p 20
A87-38810 * p 20
A87-38812 p 20
A87-38822 p 139
A87-38823 * p 136
A87-38824 p 139
A87-38825 * p 106
A87-38841 * p 106
A87-38842 p 106
A87-38843 * p 139
A87-39701 p 162
A87-39709 * p 47
A87-39710 * p 119
A87-39712 p 47
A87-39713 p 163
A87-39714 * p 163
A87-39715 * p 139
A87-39716 p 47
A87-39717 p 163
A87-39718 p 163
A87-39720 * p 48
A87-39721 * p 163
A87-39722 * p 119
A87-39723 p 167
A87-39724 * p 163
A87-39725 p 42
A87-39727 p 150
A87-39728 p 150
A87-39729 * p 48
A87-39730 * p 48
A87-39731 * p 48
A87-39732 p 48
A87-39733 * p 48
A87-39734 * p 42
A87-39735 p 48
A87-39736 p 48
A87-39737 p 48
A87-39738 p 48
A87-39739 p 164
A87-39740 * p 164
A87-39741 p 164
A87-39742 * p 119
A87-39743 p 42
A87-39747 p 150
A87-39748 p 150
A87-39749 p 48
A87-39750 p 48
A87-39751 * p 164
A87-39752 * p 50
A87-39753 p 50
A87-39754 * p 120
A87-39755 * p 134
A87-39756 * p 124
A87-39757 * p 124
A87-39760 p 42
A87-39761 * p 50
A87-39762 * p 50
A87-39763 * p 50
A87-39764 * p 50
A87-39765 p 51
A87-39766 * p 51
A87-39767 p 134
A87-39768 p 164
A87-39769 * p 134
A87-39770 * p 51
A87-39771 * p 51
A87-39772 * p 51
A87-39773 * p 51
A87-39774 p 51
A87-39775 * p 42
A87-39776 p 43
A87-39778 * p 89
A87-39779 p 52
A87-39780 p 134
A87-39781 p 134
A87-39782 p 135
A87-39783 p 180
A87-39784 * p 119
A87-39785 p 89
A87-39824 # p 21
A87-39163 p 124
A87-39428 # p 108
A87-39843 *# p 21
A87-39954 # p 151
A87-39828 # p 76
A87-39829 # p 75
A87-39[illegible] # p 58
A87-39[illegible] p 75
A87-39956 p 151
A87-39958 * p 58
A87-40051 p 1
A87-40068 *# p 167
A87-40074 # p 58
A87-40075 # p 21
A87-40798 p 164

A87-40298 p 108
A87-40319 *# p 124
A87-40329 p 151
A87-40342 p 151
A87-40351 p 2
A87-40353 *# p 120
A87-40358 p 112
A87-40359 p 112
A87-40363 p 119
A87-40376 p 135
A87-40377 p 135
A87-40379 *# p 76
A87-40380 p 95
A87-40381 p 112
A87-40510 # p 124
A87-40513 # p 151
A87-40844 # p 100
A87-40858 # p 124
A87-40859 *# p 125
A87-40866 # p 21
A87-40867 # p 58
A87-40869 # p 58
A87-41022 p 108
A87-41062 p 21
A87-41103 *# p 58
A87-41122 # p 95
A87-41145 *# p 76
A87-41152 # p 100
A87-41153 # p 100
A87-41159 *# p 21
A87-41161 *# p 135
A87-41218 p 108
A87-41219 p 151
A87-41222 p 108
A87-41352 # p 95
A87-41429 p 151
A87-41430 p 125
A87-41768 p 108
A87-41570 p 151
A87-41571 * p 108
A87-41572 p 108
A87-41573 p 136
A87-41574 p 21
A87-41575 * p 90
A87-41609 *# p 95
A87-41611 *# p 7
A87-41613 *# p 22
A87-41615 *# p 90
A87-41617 p 58
A87-41668 p 52
A87-41679 p 152
A87-41870 p 119
A87-41954 p 152
A87-42298 # p 77
A87-42299 # p 152
A87-42397 # p 108
A87-42505 # p 58
A87-42585 * p 125
A87-42613 * p 90
A87-42678 *# p 22
A87-42680 p 90
A87-42816 * p 58
A87-42817 * p 58
A87-42821 * p 112
A87-42823 p 152
A87-43003 # p 43
A87-43004 # p 77
A87-43014 # p 43
A87-43027 *# p 90
A87-43031 # p 160
A87-43046 *# p 43
A87-43058 *# p 43
A87-43060 *# p 136
A87-43103 *# p 43
A87-43122 # p 52
A87-43125 *# p 44
A87-43128 *# p 44
A87-43154 * p 125
A87-43156 p 152
A87-43165 * p 125
A87-43864 # p 125
A87-44179 * p 125
A87-44184 * p 136
A87-44185 * p 136
A87-44186 * p 136
A87-44187 * p 136
A87-44375 p 108
A87-44392 p 136
A87-44533 * p 136
A87-44688 p 22
A87-44690 p 152
A87-44741 p 108
A87-44828 *# p 44
A87-44832 # p 90
A87-44843 *# p 41
A87-45180 # p 90
A87-45181 * p 91
A87-45182 # p 135
A87-45198 # p 91
A87-45255 *# p 91
A87-45256 *# p 91
A87-45257 # p 152
A87-45258 # p 44
A87-45259 *# p 91
A87-45260 # p 91
A87-45267 # p 91
A87-45311 # p 92
A87-45357 # p 92
A87-45380 # p 92
A87-45383 # p 77
A87-45429 # p 92
A87-45441 # p 160
A87-45476 p 136
A87-45483 * p 95
A87-45485 * p 113
A87-45519 * p 95
A87-45520 p 95
A87-45521 p 113
A87-45522 p 95
A87-45523 p 2
A87-45524 * p 95
A87-45525 p 136
A87-45787 * p 100
A87-46030 *# p 136
A87-46121 p 152
A87-46281 p 58
A87-46301 * p 58
A87-46332 * p 108
A87-46693 p 44
A87-46704 # p 100
A87-46793 *# p 22
A87-46872 # p 153
A87-46873 p 108
A87-46945 p 153
A87-46975 p 108
A87-47302 p 153
A87-47327 p 22
A87-47729 p 108
A87-47809 *# p 22
A87-47810 # p 58
A87-47811 # p 58
A87-47812 *# p 22
A87-47869 p 108
A87-48156 p 101
A87-48157 p 153
A87-48234 p 77
A87-48273 * p 90
A87-48341 p 23
A87-48572 *# p 92
A87-48573 # p 153
A87-48579 # p 153
A87-48580 # p 153
A87-48581 # p 153
A87-48582 *# p 119
A87-48583 # p 113
A87-48586 # p 154
A87-48587 *# p 113
A87-48588 *# p 113
A87-48589 # p 113
A87-48590 # p 113
A87-48592 # p 154
A87-48593 *# p 114
A87-48594 *# p 108
A87-48595 # p 154
A87-48596 # p 154
A87-48597 *# p 119
A87-48600 *# p 114
A87-48601 # p 2
A87-48602 # p 7
A87-48605 # p 154
A87-48606 *# p 114
A87-48607 *# p 114
A87-48714 # p 23
A87-48826 * p 136
A87-48830 p 154
A87-48815 *# p 92
A87-48817 # p 93
A87-48818 *# p 136
A87-48797 *# p 108
A87-48867 # p 154
A87-50053 p 93
A87-50157 p 93
A87-50187 *# p 93
A87-50252 p 23
A87-50401 p 93
A87-50404 # p 93
A87-50412 *# p 7
A87-50413 p 60
A87-50414 p 60
A87-50415 # p 60
A87-50416 *# p 23
A87-50417 # p 98
A87-50442 # p 23
A87-50443 # p 23
A87-50444 # p 23
A87-50445 # p 24
A87-50446 # p 24
A87-50447 # p 126
A87-50471 *# p 24
A87-50472 # p 61
A87-50473 # p 24
A87-50474 *# p 61
A87-50475 # p 61
A87-50480 # p 61
A87-50502 # p 24
A87-50503 # p 61
A87-50504 # p 24
A87-50505 *# p 61
A87-50506 *# p 25
A87-50507 # p 25
A87-50509 *# p 93
A87-50511 # p 77
A87-50521 *# p 62
A87-50523 # p 101
A87-50558 *# p 62
A87-50561 *# p 62
A87-50562 *# p 62
A87-50730 *# p 127
A87-50762 p 154
A87-51610 p 62
A87-51713 * p 140
A87-51772 p 107
A87-51793 p 25
A87-51794 p 107
A87-51866 p 108
A87-51870 p 155
A87-51879 # p 101
A87-52247 *# p 63
A87-52252 *# p 62
A87-52450 * p 127
A87-52865 *# p 63
A87-52866 # p 25
A87-52868 # p 63
A87-52873 # p 63
A87-53002 * p 127
A87-53059 # p 101
A87-53062 * p 2
A87-53063 p 170
A87-53065 p 170
A87-53068 p 2
A87-53069 p 165
A87-53117 p 155
A87-53149 p 127
A87-53554 # p 155
A87-53556 p 155
A87-53558 p 155
A87-53560 p 155
A87-53616 # p 155
A87-53623 # p 136
A87-53624 # p 170
A87-53646 p 107
A87-53679 * p 52
A87-53686 p 170
A87-53691 p 101
A87-54116 p 63
A87-54157 p 127
A87-54186 p 127

N87-20306 *# p 136
N87-20307 *# p 25
N87-20311 *# p 170
N87-20325 *# p 165
N87-20335 *# p 136
N87-20338 *# p 64
N87-20340 *# p 120
N87-20342 *# p 165
N87-20347 p 25
N87-20348 p 26
N87-20351 *# p 120
N87-20352 *# p 26
N87-20353 *# p 44
N87-20355 *# p 26
N87-20356 *# p 2
N87-20357 # p 156
N87-20358 # p 26
N87-20359 # p 127
N87-20360 # p 96
N87-20361 *# p 26
N87-20362 # p 26
N87-20363 # p 26
N87-20364 # p 27
N87-20365 # p 27
N87-20366 # p 27
N87-20367 # p 27
N87-20368 # p 27
N87-20370 # p 101
N87-20371 # p 63
N87-20372 # p 26
N87-20373 # p 8
N87-20374 # p 26
N87-20375 p 63
N87-20376 *# p 63
N87-20380 *# p 63
N87-20477 *# p 63
N87-20564 p 26
N87-20567 *# p 28
N87-20568 *# p 25
N87-20569 *# p 28
N87-20574 # p 29
N87-20577 # p 63
N87-20581 *# p 8
N87-20584 *# p 77
N87-20586 # p 28
N87-20621 # p 128
N87-20622 # p 128
N87-20623 # p 156
N87-20624 # p 156
N87-20625 # p 128
N87-20626 # p 156
N87-20627 # p 156
N87-20628 # p 128
N87-20629 # p 156
N87-20630 # p 114
N87-20631 # p 128
N87-20632 # p 170
N87-20633 # p 161
N87-20634 # p 128
N87-20635 # p 156
N87-20636 # p 157
N87-20637 # p 161
N87-20638 # p 157
N87-20639 # p 114
N87-20640 # p 157
N87-20641 # p 128
N87-20655 *# p 64
N87-20657 *# p 170
N87-20660 *# p 64
N87-20661 *# p 64
N87-20662 *# p 2
N87-20732 # p 157
N87-20735 # p 157
N87-20774 # p 161
N87-20785 *# p 140
N87-20841 *# p 123
N87-21016 *# p 161
N87-21020 *# p 8
N87-21021 *# p 45
N87-21024 # p 140
N87-21025 # p 29
N87-21030 # p 29
N87-21141 *# p 94
N87-21142 *# p 94
N87-21143 *# p 94
N87-21144 *# p 94
N87-21145 *# p 94
N87-21146 *# p 94
N87-21147 *# p 94
N87-21148 *# p 95
N87-21149 *# p 95
N87-21150 *# p 95
N87-21151 *# p 95
N87-21152 *# p 95
N87-21153 *# p 77
N87-21154 *# p 8
N87-21155 *# p 52
N87-21158 *# p 95
N87-21208 * p 29
N87-21335 p 64
N87-21386 # p 29
N87-21585 *# p 165
N87-21681 * p 8
N87-21753 # p 170
N87-21754 # p 171
N87-21873 # p 128
N87-21879 # p 157
N87-21887 *# p 30
N87-21889 p 64
N87-21891 # p 140
N87-21892 # p 30
N87-21893 # p 64
N87-21894 *# p 65
N87-21895 *# p 8
N87-21896 *# p 157
N87-22001 *# p 65
N87-22003 *# p 65
N87-22004 *# p 78
N87-22090 p 65
N87-22174 *# p 78
N87-22201 # p 101
N87-22203 # p 102
N87-22237 *# p 66
N87-22242 *# p 102
N87-22252 # p 30
N87-22256 # p 30
N87-22289 # p 30
N87-22457 *# p 129
N87-22508 *# p 129
N87-22509 *# p 129
N87-22531 # p 137
N87-22569 # p 171
N87-22570 *# p 129
N87-22571 *# p 129
N87-22687 # p 171
N87-22702 *# p 66
N87-22703 *# p 30
N87-22704 *# p 30
N87-22705 *# p 31
N87-22706 *# p 65
N87-22707 *# p 31
N87-22708 *# p 65
N87-22710 *# p 31
N87-22711 *# p 8
N87-22712 *# p 31
N87-22713 *# p 31
N87-22714 *# p 65
N87-22715 *# p 66
N87-22716 *# p 8
N87-22717 *# p 66
N87-22718 *# p 31
N87-22719 *# p 31
N87-22720 *# p 66
N87-22721 *# p 9
N87-22722 *# p 78
N87-22723 *# p 66
N87-22724 *# p 32
N87-22725 *# p 32
N87-22726 *# p 32
N87-22727 *# p 32
N87-22728 *# p 66
N87-22729 *# p 66
N87-22730 *# p 66
N87-22731 *# p 66
N87-22732 *# p 66
N87-22733 *# p 32
N87-22734 *# p 67
N87-22735 *# p 9
N87-22736 *# p 67
N87-22737 *# p 67
N87-22738 *# p 33
N87-22739 *# p 33
N87-22740 *# p 78
N87-22741 *# p 9
N87-22742 *# p 67
N87-22743 *# p 33
N87-22744 *# p 165
N87-22745 *# p 33
N87-22746 *# p 67
N87-22747 *# p 33
N87-22748 *# p 33
N87-22750 *# p 33
N87-22751 *# p 33
N87-22752 *# p 67
N87-22753 *# p 67
N87-22756 *# p 129
N87-22758 *# p 67
N87-22761 # p 68
N87-22762 # p 120
N87-22871 # p 68
N87-23048 *# p 68
N87-23088 *# p 78
N87-23089 *# p 140
N87-23157 *# p 9
N87-23161 # p 114
N87-23174 *# p 121
N87-23577 # p 161
N87-23578 # p 140
N87-23860 # p 3
N87-23861 # p 68
N87-23862 # p 137
N87-23863 # p 34
N87-23867 *# p 68
N87-23868 *# p 68
N87-23869 *# p 78
N87-23865 *# p 79
N87-23738 * p 107
N87-23801 *# p 68
N87-23802 # p 34
N87-24026 # p 68
N87-24084 *# p 52
N87-24152 *# p 120
N87-24240 # p 171
N87-24250 # p 129
N87-24262 *# p 102
N87-24480 # p 69
N87-24481 # p 69
N87-24485 *# p 34
N87-24486 *# p 171
N87-24487 *# p 34
N87-24489 *# p 69

N87-24499 *# p 67
N87-24500 *# p 3
N87-24501 *# p 34
N87-24502 *# p 69
N87-24503 *# p 67
N87-24504 *# p 67
N87-24505 *# p 34
N87-24506 *# p 69
N87-24507 *# p 69
N87-24508 *# p 67
N87-24509 *# p 69
N87-24510 *# p 34
N87-24511 *# p 69
N87-24512 *# p 70
N87-24513 *# p 70
N87-24514 # p 70
N87-24515 p 140
N87-24516 # p 35
N87-24517 # p 35
N87-24520 *# p 35
N87-24521 *# p 70
N87-24530 # p 79
N87-24532 # p 79
N87-24533 # p 79
N87-24535 *# p 69
N87-24541 *# p 67
N87-24700 *# p 10
N87-24723 *# p 70
N87-24817 *# p 115
N87-24828 *# p 79
N87-25004 # p 171
N87-25011 # p 157
N87-25023 # p 130
N87-25030 # p 102
N87-25037 # p 102
N87-25039 *# p 137
N87-25040 # p 158
N87-25046 *# p 35
N87-25050 # p 70
N87-25051 # p 130
N87-25052 # p 71
N87-25054 # p 171
N87-25055 *# p 71
N87-25056 # p 71
N87-25057 # p 35
N87-25058 # p 71
N87-25059 # p 35
N87-25060 # p 71
N87-25066 # p 71
N87-25418 # p 158
N87-25422 *# p 67
N87-25435 # p 107
N87-25443 *# p 137
N87-25455 *# p 107
N87-25462 * p 38
N87-25538 p 130
N87-25580 # p 130
N87-25581 *# p 165
N87-25676 *# p 38
N87-25682 * p 161
N87-25683 *# p 100
N87-25685 *# p 107
N87-25695 *# p 38
N87-25696 *# p 38
N87-25700 *# p 171
N87-25707 *# p 130
N87-25851 *# p 71
N87-25856 # p 72
N87-25915 # p 171
N87-25929 *# p 79
N87-25930 *# p 67
N87-25960 *# p 115
N87-25989 *# p 72
N87-26057 # p 115
N87-26058 # p 67
N87-26062 *# p 67
N87-26063 *# p 3
N87-26064 *# p 3
N87-26065 *# p 3
N87-26066 *# p 4
N87-26067 *# p 4
N87-26071 *# p 38
N87-26072 *# p 45
N87-26073 * p 4
N87-26075 # p 38
N87-26081 *# p 67
N87-26082 *# p 141
N87-26083 *# p 130
N87-26085 *# p 37
N87-26086 *# p 53
N87-26097 *# p 137
N87-26116 *# p 88
N87-26129 *# p 88
N87-26130 # p 88
N87-26131 *# p 88
N87-26132 *# p 88
N87-26133 *# p 88
N87-26135 *# p 88
N87-26144 *# p 80
N87-26173 *# p 141
N87-26174 *# p 131
N87-26175 *# p 108
N87-26176 *# p 141
N87-26177 *# p 108
N87-26178 *# p 141
N87-26179 *# p 141
N87-26180 *# p 108
N87-26181 *# p 137
N87-26182 *# p 108
N87-26183 *# p 141
N87-26185 *# p 4
N87-26186 *# p 141
N87-26188 *# p 131
N87-26189 *# p 108
N87-26190 *# p 108
N87-26191 *# p 131
N87-26192 *# p 45
N87-26197 *# p 108
N87-26198 *# p 108
N87-26200 *# p 109
N87-26201 *# p 109
N87-26202 *# p 109
N87-26203 *# p 110
N87-26204 *# p 142
N87-26205 *# p 10
N87-26206 *# p 110
N87-26207 *# p 142
N87-26266 p 102
N87-26268 *# p 37
N87-26270 *# p 37
N87-26367 p 37
N87-26387 *# p 37
N87-26414 *# p 80
N87-26424 *# p 80
N87-26426 *# p 80
N87-26447 *# p 80
N87-26448 *# p 131
N87-26452 *# p 80
N87-26505 *# p 38
N87-26506 *# p 115
N87-26590 *# p 80
N87-26700 *# p 72
N87-26703 *# p 53
N87-26841 p 121
N87-26842 p 158
N87-26921 p 38
N87-26927 *# p 137
N87-26936 *# p 45
N87-26937 # p 142
N87-26942 # p 142
N87-26945 *# p 142
N87-26949 # p 142
N87-26952 # p 143
N87-26953 # p 158
N87-26954 # p 143
N87-26957 # p 143
N87-26959 # p 67
N87-26960 # p 67
N87-26961 # p 67
N87-26964 # p 172
N87-26966 # p 72
N87-26967 # p 131
N87-26968 # p 100
N87-26970 p 72
N87-27299 # p 38
N87-27300 *# p 38
N87-27302 *# p 53
N87-27405 *# p 53
N87-27407 *# p 53
N87-27408 # p 100
N87-27412 *# p 10
N87-27443 *# p 115
N87-27687 # p 158
N87-27688 # p 158
N87-27689 # p 158
N87-27695 # p 158
N87-27696 # p 158
N87-27702 *# p 45
N87-27704 *# p 72
N87-27705 # p 38
N87-27706 # p 73
N87-27707 # p 73
N87-27708 # p 73
N87-27709 # p 73
N87-27712 *# p 73
N87-27713 * p 38
N87-27859 # p 110
N87-27865 # p 158
N87-28108 # p 81
N87-28109 *# p 81
N87-28260 # p 100
N87-28405 # p 88
N87-28577 p 130
N87-28581 *# p 39
N87-28582 *# p 39
N87-28583 *# p 4
N87-28584 # p 110
N87-28585 # p 115
N87-28586 # p 115
N87-28589 # p 130
N87-28625 *# p 81
N87-28637 p 39
N87-28658 # p 81
N87-28660 # p 81
N87-28661 # p 81
N87-28669 # p 158
N87-28672 # p 81
N87-28673 # p 82
N87-28674 # p 158
N87-28675 # p 82
N87-28676 # p 82
N87-28677 # p 82
N87-28679 # p 82
N87-28680 # p 82
N87-28681 # p 82
N87-28682 # p 82
N87-28684 # p 83
N87-28685 # p 83
N87-28686 # p 83
N87-28688 # p 158
N87-28689 # p 159
N87-28692 # p 10
N87-28694 # p 83
N87-28695 # p 83
N87-28699 # p 100
N87-28910 # p 83
N87-28912 # p 39
N87-28915 # p 159
N87-29004 # p 159
N87-29117 *# p 53
N87-29118 * p 100
N87-29124 *# p 116
N87-29127 *# p 116
N87-29128 *# p 116
N87-29129 *# p 10
N87-29144 *# p 116
N87-29145 *# p 116
N87-29146 *# p 116
N87-29148 *# p 116
N87-29149 *# p 116
N87-29150 *# p 116
N87-29151 *# p 117
N87-29152 *# p 117
N87-29153 *# p 117
N87-29156 *# p 172
N87-29157 *# p 117
N87-29160 *# p 117
N87-29161 *# p 88
N87-29162 *# p 73
N87-29163 *# p 4
N87-29164 *# p 5
N87-29165 *# p 117
N87-29166 *# p 117
N87-29167 *# p 117
N87-29169 *# p 130
N87-29217 # p 46
N87-29563 # p 160
N87-29579 * p 39
N87-29583 # p 5
N87-29585 *# p 131
N87-29589 *# p 39
N87-29591 *# p 131
N87-29593 *# p 103
N87-29594 *# p 54
N87-29633 *# p 132
N87-29709 # p 110
N87-29713 *# p 74
N87-29848 *# p 100
N87-29858 *# p 40
N87-29860 *# p 40
N87-29861 *# p 161
N87-29864 *# p 40
N87-29865 *# p 104
N87-29866 *# p 104
N87-29867 *# p 104
N87-29868 *# p 104
N87-29869 *# p 104
N87-29876 *# p 162
N87-29877 *# p 138
N87-29878 *# p 138
N87-29879 *# p 104
N87-29882 *# p 83
N87-29883 # p 11
N87-29886 *# p 40
N87-29889 *# p 40
N87-29914 *# p 5
N87-29915 *# p 84
N87-29916 *# p 5
N87-29917 *# p 84
N87-29920 *# p 88
N87-29933 *# p 74
N87-29939 *# p 84
N87-30107 *# p 11
N87-30220 # p 172
N87-30221 # p 172

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1. Report No.
NASA SP-7056 (06)

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
Space Station Systems
A Bibliography with Indexes

5. Report Date
July, 1988

6. Performing Organization Code

7. Author(s)

8. Performing Organization Report No.

9. Performing Organization Name and Address
National Aeronautics and Space Administration
Washington, DC 20546

10. Work Unit No.

11. Contract or Grant No.

12. Sponsoring Agency Name and Address

13. Type of Report and Period Covered

14. Sponsoring Agency Code

15. Supplementary Notes
Compiled by Technical Library Branch and edited by Space Station Office, Langley Research Center, Hampton, Virginia.

16. Abstract

This bibliography lists 1,133 reports, articles and other documents introduced into the NASA scientific and technical information system between July 1, 1987 and December 31, 1987. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future Space Station.

17. Key Words (Suggested by Authors(s))
Space Stations
Space Platforms
Space Technology Experiments
Space Erectable Structures

18. Distribution Statement
Unclassified - Unlimited

19. Security Classif. (of this report)
Unclassified

20. Security Classif. (of this page)
Unclassified

21. No. of Pages
286

22. Price *
A13/HC

286

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